AD-777 747

ARPANET MANAGEMENT STUDY

Paul Baran, et al

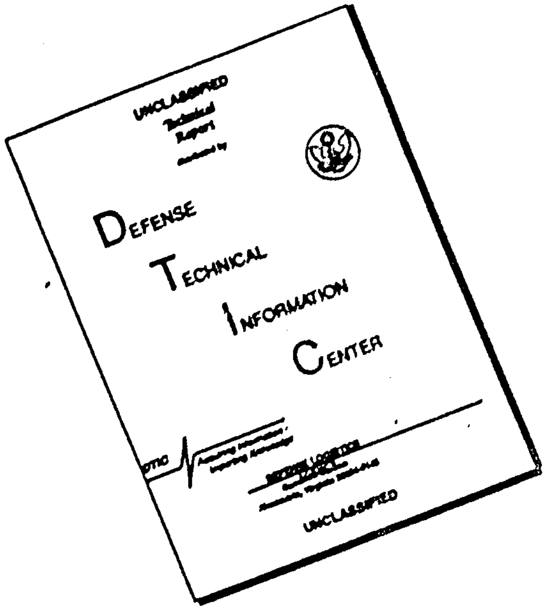
Cabledata Associates, Incorporated

Prepared for:

Advanced Research Projects Agency

20 January 1974

DISCLAIMER NOTICE



THIS DOCUMENT IS BEST QUALITY AVAILABLE. THE COPY FURNISHED TO DTIC CONTAINED A SIGNIFICANT NUMBER OF PAGES WHICH DO NOT REPRODUCE LEGIBLY.

REPORT DOCUMENTATION PAGE

READ INSTRUCTIONS BEFORE COMPLETING FORM

1. REPORT NUMBER DI-S-3591/S-117-1/M	2. GOVT ACCESSION NO.	3. RECIPIENT'S CATALOG NUMBER

4. TITLE (and Subtitle)

ARPANET MANAGEMENT STUDY

5. TYPE OF REPORT & PERIOD COVERED

Final Technical Report
1973 March-December

6. PERFORMING ORG. REPORT NUMBER

R-123

7. AUTHOR(s)

Paul Baran
David C. Caulkins
Vinton G. Cerf
Ronald C. Crane
Paul Goldstein
Robert S. O'Brien
Edwin B. Parker
Marc U. Porat

8. CONTRACT OR GRANT NUMBER(s)

Contract Number
F08606-73-C-0036

9. PERFORMING ORGANIZATION NAME AND ADDRESS

Cabledata Associates, Inc.
701 Welch Road
Palo Alto, CA 94304

10. PROGRAM ELEMENT, PROJECT, TASK AREA & WORK UNIT NUMBERS

11. CONTROLLING OFFICE NAME AND ADDRESS

Defense Advanced Research Projects Agency
1400 Wilson Boulevard
Arlington, VA 22209

12. REPORT DATE

1974 January 20

13. NUMBER OF PAGES

312

14. MONITORING AGENCY NAME & ADDRESS (if different from Controlling Office)

Range Measurements Laboratory
Building 981
Air Force Eastern Test Range
Patrick Air Force Base, FL 32925

15. SECURITY CLASS. (of this report)

Unclassified

15a. DECLASSIFICATION/DOWNGRADING SCHEDULE

16. DISTRIBUTION STATEMENT (of this Report)

Distribution of this document is unlimited.

17. DISTRIBUTION STATEMENT (of the abstract entered in Block 20, if different from Report)

Distribution of this document is unlimited.

18. SUPPLEMENTARY NOTES

None.

19. KEY WORDS (Continue on reverse side if necessary and identify by block number)

ARPANET, Communications, Computer Netting, Divestiture, Packet Switching, Regulation.

20. ABSTRACT (Continue on reverse side if necessary and identify by block number) Examines issues affecting the long range development of the ARPANET in general. Considers the near-term question of possible divestiture of the ARPANET in specific and reviews the background of the network to better describe present context. Proposes specific steps to meet primary ARPA objectives for the future. Basically, calls for encouragement of interaction and cooperation by organizations providing packet switching services. If successful inter-network connection could become economically and operationally feasible, this would permit ARPA to divest, on incremental test basis, those portions of the network not required for experimental purposes.

C A B L E D A T A   A S S O C I A T E S, I N C.

701 Welch Road • Palo Alto, California 94304

ARPANET MANAGEMENT STUDY

FINAL TECHNICAL REPORT

DI-S-3591/S-117-1M

This research was supported by the Advanced Research Projects Agency of the Department of Defense and was monitored by the Range Measurements Laboratory under Contract No.: F08606-73-C-0036.

ARPA ORDER NUMBER *2317*	CONTRACT NUMBER *F08606-73-C-0036*
PROGRAM CODE NUMBER 62706E/3P10	PRINCIPAL INVESTIGATOR & PHONE NO. *Paul Baran - (415) 328-2411*
NAME OF CONTRACTOR *Cabledata Associates, Inc.*	PROJECT SCIENTIST & PHONE NO. *Vinton G. Cerf - (415) 328-2411*
EFFECTIVE DATE OF CONTRACT *1973 April 30*	SHORT TITLE OF WORK *ARPANET Management Study*
CONTRACT EXPIRATION DATE *1974 January 24*	DATE OF REPORT *1974 January 14*
AMOUNT OF CONTRACT *$118,965.00*	CONTRACT PERIOD COVERED BY REPORT *1973 March - December*

1a

SUMMARY AND CONCLUSION

This study examines some of the issues affecting the long range development of packet switching in general. It specifically considers the role of the ARPANET in this development. The near-term question of transfer of a portion of the communications portion of the ARPANET is examined in detail, and the background of the development of the network is discussed to place the key issues in perspective.

A plan for the transfer of the communications portion of the ARPANET (and not the host resources) is proposed which is based upon the encouragement of interaction and cooperation among organizations providing packet switching services. If successful, effective internetwork connection could become economically and operationally feasible. This would permit ARPA the option of transferring, on an incremental test basis, the portion of the network not required for experimental purposes.

In the proposed plan (described in Sections 3 and 4 of the report),

1. ARPA would transfer the service aspects of the network not needed to carry out experiments in packet switching technology.

2. ARPA would retain or create an experimental packet switching subnet on which it would test satellite communications methods, packet radio, network interconnection methods, and other ideas.

The transfer itself would provide new means for sharing of the packet switching subnet between private and public sectors under the aegis of a "consortium" in a legal and harmonious fashion, with minimal need for FCC control.

The initial reasons behind the development of the ARPANET remain valid today. Those reasons include:

1. The desire to use ARPA-owned or -funded resources more effectively (resource sharing).

2. The desire to obtain low cost computer communication facilities necessary for resource sharing. This requires both high bandwidth (e.g., file transfer) and low delay (e.g., interactive) traffic to be serviced.

3. An interest in applying experimental packet switching techniques to communication development to overcome limitations of conventional data communications: high error rates, low bandwidths, inflexible topologies and limited reliability.

4. The need to develop alternatives for military communication systems having lower cost, lower delay and higher bandwidth capabilities than those currently in use, while still providing the end-to-end security and reliability needed.

The ARPANET project has been successful in several ways:

1. The technical feasibility of packet switching for terminal-to-computer and computer-to-computer communication has been demonstrated at marginal costs lower than any present alternative.

2. Common protocols which allow diverse host computers to communicate with one another have been designed and implemented at virtually all sites in the network. The network has provided a good test bed for exploring solutions to problems of interprocess communication, distributed operating system design, interfacing diverse operating systems, security and privacy, accounting, and reliability.

3. Effective sharing of the network's resources among users and host computers has been achieved. This sharing has permitted closer interaction among researchers in the network community, made better use of limited computer resources and has demonstrated new capabilities in computer science and project management.

4. Research into new communication methods based on packet switching (e.g., packet radio, packet broadcast satellite) is now under way, largely spurred on by the initial success of the ARPANET packet switching experiment.

After reviewing the status of the ARPANET, we then considered a set of major issues now facing the network. These issues included:

1. The continuing need to provide ARPANET-based services to ARPA contractors on a high reliability basis.

2. The need for similar services by other governmental agencies.

3. The desire for ARPANET-type services by the civilian sector.

4. The desirability and problems of interconnection with other national and international networks.

5. The proper role of ARPA as a research organization committed to the concept of technological transfer when research matures into proven feasibility.

6. The on-going role of ARPA in developing the computer resource sharing concept.

In this study we have reached a number of conclusions which we state below as recommendations:

1. We recommend that the commercial packet switching industry be encouraged to provide the additional capacity that ARPA and new governmental applications will be seeking from the present ARPANET, rather than permit an open-ended expansion of the ARPANET communications network.

2. We recommend that ARPA continue full ownership and control of those parts of the ARPANET needed for experimentation in improvements in packet switching.

3. We recommend that the nation develop a unified packet switching service accessible to all users on an equitable basis, rather than encourage a collection of isolated packet networks that cannot share specialized computer resources.

4. We believe that more effective use of limited national communications resources would occur if all packet networks were built so as to permit interconnections with one another and recommend that it be encouraged by ARPA.

5. We believe that the healthy development of the packet switching industry will be of significant importance to the development of the computer resource sharing capability of the country and recommend that it be encouraged.

6. We believe that the transfer of the ARPANET communications facilities should not, as a matter of public policy, lead to the creation of any monopoly on future packet switching by any potential bidder. To this end we recommend that new means be created to permit the suppliers of packet switching to work together to create and maintain a healthy competitive environment while supplying competitive services.

7. Inasmuch as no presently suitable arrangement exists for accomplishing these objectives, we recommend the specific plan which is described in detail in this report. This plan is based upon the formation of an industry group or consortium. The form and name of the institutional structure is secondary, provided that it contains effective provision for the following three essential functions:

A. A clearinghouse mechanism for transferring payments among cooperating entities.

B. A mechanism for creating and enforcing common industry standards.

C. A mechanism to allow continuously free and open entry, to avoid formation of any closed oligopolistic structure that will demand close governmental supervision or regulation.

CONTENTS

1. INTRODUCTION

CONTENTS

This report summarizes a ten-month study on aspects of the future evolutionary development of the ARPANET. In specific, we consider the question of transfer of ownership of the communications portions of the ARPANET to meet the growing demand for these types of services.

The introductory section of this report describes the goals of this study; the emphasis and purpose; the methodology used; and the location of the component sections of this study.

Section 2 of this report considers the near-term question of transfer; reviews the initial objectives of the ARPANET; considers its present status; and differentiates between the conflicting network needs for providing reliable services and for providing a vehicle for experimentation. Section 2 also considers ARPA's charter in providing policy guidance as to allowable directions of alternative policies. The question of increasing demand for ARPANET services is next discussed and is followed by a consideration of the desirability of reducing the management burden to ARPA. Lastly in this section is a discussion of commercial interest in packet switching and some of the implications of the expected availability of this new capability.

Section 3 of this report starts with some of the basic postulates underlying a possible proposed course of action. A proposed transitional divestiture strategy is suggested, based heavily upon the concept of a packet switching industry cooperative arrangement. This approach opens some new options to ARPA which are considered. Because the idea of a "consortium" is

relatively new, it is described briefly in Section 3 and in very much greater detail in Appendices B through F.

The last section of the report, Section 4, proposes a specific action plan for a partial test transfer of ownership of parts of the ARPANET under tight control to protect other users of the existing network. This section of the report is not intended as a take-it-or-leave-it proposition. Rather, it is intended as a proposed plan that would benefit from industry review and modification, where necessary, to provide an eventual plan that all parties would find acceptable in the belief that it would accomplish its desired objectives. Section 4 is written in question and answer form to facilitate the reader's skipping over sections of detail that are only of minor interest.

We sought to keep the basic report short. If the reader has little time, reviewing the summary will tell much of the story. If the reader has a little more time, then the full report can be read, as it is only about 30 pages in length. However, much of the report resides in the appendices. But, these are arranged to be read in stand-alone fashion.

The appendices of this report are arranged in three groups, with yellow divider sections used to facilitate the reader in pinpointing individual sections of interest. Blue dividers are used to separate the appendices.

The first, Appendix A, was prepared by Paul Goldstein. It stands alone and provides legal background analysis important to the question of the transfer of the ARPANET. This appendix shows, among other matters, that governmental regulation is a substitute for competition, and is needed only where the open marketplace is unable to achieve effective competition. This appendix also views regulation and non-regulation not as binary concepts, but as shades of gray issues. Some of these fine shadings are of importance to the question of transfer of ownership of government resources to private ownership, present in possible transfer of the ARPANET.

The next group of appendices, Appendices B through F, relate to institutional alternatives and were prepared primarily by Marc U. Porat.

The first, Appendix B, reviews alternative industrial structures possible; describes the present trajectory of development towards one of these possibilities as being most likely, unless active reconsideration is taken; and describes the writer's preferred course of action together with the reasons for his position. In support of his arguments, useful background information is presented reviewing some of the most recent changes taking place in communications regulation.

Appendix C is a detailed description of the operation of a possible consortium or industry association of packet switching entities including suppliers and users. This provides fine grain detail discussion of the day-to-day procedural operation of an imaginary consortium. It provides a flavor of how such an imaginary organization might work. Much detail is included in this report since the concept of a consortium has not been considered before in this application. The detail is intended to aid discussion about possible organizational arrangements.

The third appendix in this series, Appendix D, is a Delphi exercise prepared early in this study. In this, the staff considered a spectrum of alternative options; narrowed them down to four major ones and then expressed their subjective judgments. Considered were differences in the characteristics, and expected operational behavior. This appendix suggests the broad range of alternative institutional arrangements initially considered and some of the reasons why certain arrangements were narrowed for further investigation.

Appendix E is a simulation also performed early in the project. It examines the expected behavior patterns of competing organizations in the hypothetical situation where such organizations owned different segments of a single network, and where strict rules of behavior, specified in advance, were followed.

This appendix addresses the question as to whether actions beneficial to the entire network would result if each separate owner made decisions solely in its own best interest. The appendix shows how one might go about programming this behavior to predict performance in advance of a real world situation.

Lastly, in this set of appendices on institutional arrangements, is Appendix F, which is the Users Manual for the simulation model.

The last four appendices, G through J, relating to ARPANET communications facilities economic issues, were prepared by Ronald C. Crane. They describe a cost model structure for estimating the costs involved in the ARPANET and provide a "do-it-yourself" kit of tools and a data base. They allow the user to consider any combination of ARPANET elements in place at any point in time, producing output analyses under a wide set of depreciation assumptions and costing bases.

GOALS

Below, we list the factors that form the impetus and goals of this study.

1. ARPA is facing major decisions during the next few years on the growth, development and possible ownership of the ARPANET. There are major implications for state-of-the-art of computer system development that hinge upon some of these decisions.

2. Much of the work in this project consisted of detailed consideration of the alternatives viewed from different dimensions, including: technical desirability, regulatory constraints, management effectiveness, legal constraints, economic factors, and the specific impacts upon each affected community of interest.

3. The basic goal sought is that of creating a specific plan of action that will provide the greatest long range benefit to the nation in return for its past, present and future involvement and investment in the ARPANET.

4. All policy decisions that result from this effort will be the responsibility of ARPA/IPT. This work is intended only to provide ARPA with background policy research to facilitate its policy making role.

EMPHASIS

Unlike most research studies, we sought not a single "correct" answer, but rather we explored a large set of alternatives. Each alternative considered has been evaluated, but the final choice is left to the sponsor of the study.

In any examination of this type, the ideal degree of detail is almost open-ended and probably depends more upon the amount of time that the researcher has available than any other factor. Thus, at the initiation of this study we prepared a systematic "effort tree" or effort-weighted outline of the dimensions of the issues that form the context of the topic. We questioned the sponsor, the Information Processing Techniques Office of the Defense Advanced Research Projects Agency, as to what it felt were the most important topics to be considered and how should the limited effort best be expended.

This procedure provided a formal structure for selecting a part of a broad initial menu for narrower analysis. The narrowing down of the menu was performed in discussions with Dr. Lawrence G. Roberts. In brief, emphasis was to be given primarily to those questions that related directly to transfer, and how it might be accomplished.

HOST ECONOMICS

Although the resources represented in the ARPANET are primarily in the host computer installations, we were specifically asked not to consider the economics of the host installations in order to provide emphasis to the communications network matters per se. This was done, as only the network itself was being considered for divestiture at that time. This limitation was very important because the investment in the host computers in connection with the ARPANET is much greater than the cost of the communications network subsystem considered in detail in this study. Of course, some examination of host economics was investigated because the cost for communications

processing within the TENEX operating system appears in excess of other communications cost. Because of this disparity, the reader should be cautioned that detailed attention should be given to the economics of the host computers in estimating total costs. Host costs posed a bit of a problem because the actual use of the host computers is neither rigorously monitored nor, in our opinion, adequately understood.

2. PROBLEM STATEMENT

CONTENT

This section of the report considers the near-term question of possible transfer of the ARPANET, and reviews the background of the network to better describe its present context. The following section proposes steps to meet this ARPA objective.

This report proposes a plan which calls for the encouragement of interaction and cooperation by organizations providing packet switching services with the goal that widespread internetwork connection could become economically and operationally feasible. This would in turn allow ARPA to transfer, on an incremental test basis, those portions of its network not required for experimental purposes and thus allow shared internetwork usage.

INITIAL OBJECTIVES

It is helpful to review the initial reasons behind the development of the ARPANET so that the longer term goals are kept in mind. The initial impetus came from several directions, including:

1. The desire to use ARPA-owned or -funded resources more effectively (resource sharing).
2. The desire to obtain low cost computer communication facilities necessary for resource sharing. This requires both high bandwidth (e.g., file transfer) and low delay (e.g., interactive) traffic to be serviced.
3. An interest in applying experimental packet switching techniques to communication development to overcome limitations of conventional data communications: high error rates, low bandwidths, inflexible topologies, and limited reliability.

4. The need to develop alternatives for military communication systems having lower cost, lower delay and higher bandwidth capabilities than those currently in use, while still providing the end-to-end security and reliability needed.

STATUS

The ARPANET project has been successful in several ways:

1. The technical feasibility of packet switching for terminal-to-computer and computer-to-computer communication has been demonstrated at marginal costs lower than any present alternative.

2. Common protocols which allow diverse host computers to communicate with one another have been designed and implemented at virtually all sites in the network. The network has provided a good test bed for exploring solutions to problems of interprocess communication, distributed operating system design, interfacing diverse operating systems, security and privacy, accounting, and reliability.

3. Effective sharing of the network's resources among users and host computers has been achieved. This sharing has permitted closer interaction among researchers in the network community, made better use of limited computer resources and has demonstrated new capabilities in computer science and project management.

4. Research into new communication methods based on packet switching (e.g., packet radio, packet broadcast satellite) is now under way, largely spurred on by the initial success of the ARPANET packet switching experiment.

SERVICES VS EXPERIMENTATION

Conflict Between Service and Network Experimentation Needs

The success of resource sharing and the building of inter-site protocols has required that the packet switching network offer a stabilized service with good reliability and low error rates. Experiments with the packet switching subnet have been limited to some extent by the constraint that the network must remain operational. Some small scale experimenting can and has been done at Bolt, Beranek, and Newman with IMPS or TIPS which are under construction and testing. In-house networks of three or four nodes can be created from equipment scheduled for shipment.

However, full-scale experiments on the ARPANET have been curtailed owing to the demand for a functional network.

As an example for the problems that occur when the functions of service provision and network improvement compete, consider the following case. In late 1971, it became apparent that serious problems were being encountered with the flow control mechanism in the IMP system. BB&N set about to design a new flow control system. By mid-1972 the revised system was ready for installation after undergoing extensive testing in the laboratory on a small scale network (3-4 nodes). In the ensuing several months, attempts to install this system met with unexpected disasters. The BB&N staff were limited to one try per week (Tuesday mornings) and it took about 2 1/2 months before the new version was stable enough to be used operationally. The usual "flaky" period followed, with minor bugs discovered as the system was exercised (e.g., collecting statistics caused the net to crash).

Separating Resource Sharing and Switching Experiments

In the belief that many experiments are yet to be tried on the net, it becomes timely to plan to separate these network experiments from the resource sharing experiments. Provision for experiments with the packet switching network (e.g., satellite usage, packet radio, very high multi-megabit bandwidths, interconnection of packet switching networks) can be met by forming an experimental subnetwork, distinct from the service network. Of course, a host may be on both nets, but the nets should be independent of one another.

CHARTER RESTRICTIONS

There are other important reasons for making a clear distinction between experimentation and service. By its charter, ARPA is not in the service business; it is a research agency. Of course, it can and must purchase services to carry out its research program, so that ARPA will always need services to support its research. By separating and distinguishing its

anticipated needs for various experiments, ARPA will help pave the way for transfer, in some form, of the part of the network which it can no longer justify managing without disruption to its netting research. ARPA can exercise long term leverage on the evolution of commercial packet switching through a carefully planned transfer which acts beneficially on the development of commercial packet switching services.

DEMAND FOR ARPANET SERVICES

Nature of the Demand

The payoff of the ARPANET's unique capabilities for resource sharing has been sufficiently visible to interest many non-ARPA supported groups in connecting their computing facilities to the network. This interest, for the most part, cannot always be met because of the present restrictions on access to the ARPANET. This demand for access is multi-dimensional. Sometimes it is sought by computer center directors seeking to sell unused computer time. Sometimes it is sought as a low cost answer to the requirement for stable computer communication service spanning the continental U.S. and Hawaii.

Experienced Demand

Many groups in the private, public and military sectors have requested access to the ARPANET. Some of these requests have been accommodated through issuing ARPA contracts. Others in the government sector have access by direct transfer of funds to ARPA and many have simply been turned down or have not met the DoD guidelines under which access could be granted.

Expected Demand

The demand for interconnection is likely to continue and, more likely, to increase. The benefits of the unique national computer communication capability offered by the ARPANET among the connected sites include:

1. Better shared computer interaction among researchers.

2. Rapid sharing of results via file transfers and convenient message exchange.

3. Better sharing of software, computation and data resources.

The payoffs for these features appear to be sufficiently well understood so that the pressure for access will not go away of its own accord by those not now connected with ARPA's research program. The political pressure on ARPA for access will increase, while extending ARPA support for all these interested groups is impractical. Thus, the question that must be addressed is how to respond to a real need without disrupting ARPA's on-going interests. Therefore, we shall seek ways to allow both ARPA and non-ARPA groups to share packet switching communications resources.

REDUCTION OF MANAGEMENT BURDEN

The Problem

Since 1968, ARPA/IPT has borne almost all of the cost of maintaining, improving and operating the network. The most time-consuming aspect of network management to the small IPT staff has been the allocation of computing resources on the network to the research projects sponsored by ARPA. Provision of computing resources to one network site from another requires a conscious policy decision and paperwork authorizing expenditure of funds, as each request is unique. The issue is not a matter of a tangible dollar saving since transfer of any part of the network is not expected to reduce the immediate out-of-pocket costs to ARPA for services. Rather, the administrative issues represent a drain on ARPA's management resources which might better be spent on research management.

Interim Administration

ARPA/IPT has already reduced the management impact on its administrative staff to some extent by funding the following organizations for administrative tasks:

a) BBN NCC (Network Control Center).

b) BBN (operation and management of the network).

c) MITRE (facilitation of new attachees).

d) SRI NIC (network Information Center).

Nevertheless, each of the administrative groups must still be coordinated by ARPA/IPT.

In comparing alternative transfer plans, all things being equal, we would tend to favor those approaches which reduce ARPA/IPT administrative responsibility for the service functions of the net to the greatest extent commensurate with ARPA long range goals. This in turn causes us to give our attention to commercial availability for the service functions desired and their control by the marketplace. For example, as an extreme, we might imagine turning to a free market in which the research sponsor provided raw dollars for each project's computational requirements, with the proviso that each site spend its money as it sees fit for computing resources and computer communications. Such a strategy delegates the funding policy decisions to each site, freeing ARPA/IPT from this task. However, effective resource sharing would still require a close awareness of available resources at each site by every other site and there may be practical factors that will limit the effectiveness of this approach.

The next section discusses some of these constraints in detail.

COMMERCIAL INTEREST IN PACKET SWITCHING

There are several companies interested in entering the general packet switching business as purveyors of services to all comers, as well as being interested in supplying networks (or parts of a common network) for specific applications. Could ARPA buy the services it needs from such companies in lieu of the ARPANET? Of course, this is a real possibility, but as a minimum, ARPA should be prepared to spend more for such services than it is presently paying: partly, because some of the costs of the ARPANET are buried in other budgets; partly, because of

the extra marketing and overhead costs involved in operating, as well as possibly more expensive line costs.

A key question, regardless of cost, is whether the ARPA network itself offers a commercially viable nucleus around which a packet switching industry can develop. The present topology of the ARPA network does not span the center of commercial computing usage in the United States. New York, Chicago and Texas are not even represented. Many more nodes would have to be added (in Los Angeles, San Francisco, Boston, Chicago, Dallas, Houston, Detroit, St. Louis, Seattle, New York, etc.) before adequate access could be had to network resources by commercial computing centers. IMP and TIP equipment presently in use by the ARPANET employs Honeywell DDP-516 and 316 machines. These computers are 10-year old technology, with severe memory size limitations, obsolete architecture and expensive components. Newer minicomputers which utilize solid state memories, LSI logic and microprogramming offer lower cost and increased flexibility.

Thus, the ARPA network is seen as a small nucleus focused on support of a research community rather than service to large commercial markets. ARPA network technology is aging fast and its topology is not ideally suited to the support of a nationwide commercial service.

Given the new technologies emerging (HSMIMP multiprocessor SUE, satellite IMPS, packet radio), the present ARPANET in toto as a closed system is not an ideal business venture. Initial ownership is desirable more for providing momentum to a new company than in its tangible value. If, however, the price of the net is sufficiently low, and the price for providing services to ARPA customers is sufficiently high, it would be of interest.

3. TOWARDS A RECOMMENDATION

GENERAL POLICY STATEMENTS

Given the background situation as described, the following postulates form the basis upon which we shall propose a specific recommended course of action:

1. It is in the nation's interest in best using resources to encourage computer resource sharing.

2. The development of the packet switching industry will aid resource sharing.

3. Better use of national communication and computation resources could occur if all packet networks were built so as to readily interconnect with one another. The nation could develop a unified service accessible to all users on an equitable basis rather than isolated networks.

4. ARPA should not dispose of the ARPANET merely to underwrite the funding of a commercial service. Not only would it be inappropriate to use ARPA funds as venture capital for the support of any single packet switching service entrepreneur, but also, a sale of the entire network to a sole bidder could conceivably impede that bidder's ability to adjust to or introduce new technology.

5. A conservative policy could be to adopt a "wait and see" attitude (observe which commercial offerings survive trial by fire, and purchase service from those which appear to be technically and economically sound.)

6. A more active policy has much to recommend itself. In such a plan, ARPA would stimulate the commercial development of packet switching technology, for example, by release of all technical details of present system design paid for by ARPA funding and actively extend the present understanding of network design and its performance.

7. The government can also influence this unified packet switching development by the magnitude of its demand for computing power. It could, for example, require a commitment to meet all present and future network interconnection standards from firms supplying packet switching services to

the government.. Separate commercial networks may be nervous about interconnecting, the primary barrier being reluctance of Company A to guarantee quality of service to those customers dependent on the performance of both A's net and that of autonomous Company B. Unless there is a mechanism for the enforcement of performance standards and transfer payments, the goal of easy interconnection may remain elusive.

A PROPOSED TRANSITIONAL TRANSFER STRATEGY

The Concept of the Packet Switching Industry Cooperation Arrangement

As a matter of public policy we would prefer to see the packet communications industry encouraged to develop in a manner non-conducive to monopoly. As such, it would do well to have the characteristics of low cost of entry, free competition and enforceable interfacing standards to aid the harmonious interconnection of private, public and military networks.

Appendices B and C, which deal with organizational and institutional matters, consider the establishment of a non-profit mechanism for cooperation, perhaps a government-industry activity or consortium, which could administer the interconnection of participating networks, provide for a clearinghouse operation for use made by one network of another and insure standards of performance.

At present, the government is both a supplier and user of packet communications. Therefore, entry should be open to all private, public or military agencies having a packet network. (Networks as small as one IMP and one TIP could be eligible.) This industry association, or cooperative, or consortium would function as a settlements clearinghouse and as a coordinator. We believe that it would be appropriate that ARPA be one of the founding members, along with any of the fledgling packet switching firms.

Interconnection standards (hardware and software) would be developed and agreed upon by the consortium membership and internally administered. However, recommendations by CCITT or ISO might also be adopted and enforced by the consortium, as well as NBS standards.

Upon establishment of the consortium, ARPA at its convenience, could divest those parts of its network which are not directly related to ARPA research goals (e.g., AEC, HEW, and other DoD sites) by having them join the consortium and by transferring ownership of their IMPS or TIPS in exchange for funds and/or services.

Under the rules of the consortium, distinct networks could bilaterally or multi-laterally arrange interconnections. ARPA may choose to allow some members to connect directly to its network via packet switches (IMP-IMP) and others via *gateways**. In those cases where ARPA allows direct connection, it would dictate points of interconnect, thereby controlling its own topology. All other interconnections could be via *gateways* which are attached to IMPS designated by ARPA. If there are any initial problems encountered with the joint use of AT&T telephone circuits by members of the consortium, the procedure making all subscribers co-leasors of the lines (such as used by Tymnet) could be used. The consortium network will need facilities similar to those on the ARPANET (a NIC, NCC). These could be supplied from the commercial sector (as in the case of Tymshare's NLS for ARPA) and funded out of consortium fees. In the initial periods of operation it is likely that consortium members will all be owners of IMPS and TIPS. Eventually, other whole packet switching networks could join.

NEW OPTIONS

Once ARPA has accomplished its two short-term objectives of (1) separating the SERVICENET from the RESEARCHNET and (2) using the SERVICENET, or some portion of it, as the vehicle for catalyzing the consortium, it can decide what to do with the remaining network.

1. ARPA could sell the network and lease it back from a private firm as control and interconnect management problems are solved.

---

* V. Cerf and R. Kahn, "A Protocol for Packet Network Intercommunication," to appear in *IEEE Transactions on Communications*, May 1974.

2. ARPA could sell the network equipment and purchase services from one or more consortium companies for its contractors.

3. ARPA could write off the network, use it for experimentation, etc., and simply allocate funds to its contractors who can then choose from companies U, V, W, W, Y...the computing services they desire. If U and Y are members of the consortium, then resource sharing can continue among the ARPA research contractors.

ESTABLISHING THE CONSORTIUM

A number of options have been considered. In the main, it is most in keeping with ARPA's historic role that it be a catalytic agent and fade out of the picture of the consortium, as it would no longer be supplying services, even to itself. One possible strategy could have RML sponsor a small industry group to create the shell of the consortium as a non-profit industry organization. In this case RML would, over the short term, continue to administer the network -- but bypassing non-ARPA expansion -- to other members of the consortium. Transfer of non-ARPA portions of the network could occur in an orderly fashion. Service centers now on the network could purchase their IMPS and join the consortium, expanding their markets in the process, if they wished.

Over the long term, ARPA could consider the various transfer options for the service portion of the current ARPANET while retaining as separate and distinct an experimental research network which is not part of the consortium. (Host computers would be allowed to reside on more than one network.) RML could continue to serve ARPA in the administration of the experimental network, but would relinquish direct responsibility for the SERVICENET upon its transfer.

Therefore, in summary of the proposed Transfer Plan:

1. ARPA would divest itself of the *service* aspect of the ARPANET,

2. ARPA would retain or create an experimental subnet on which it can test satellite communication, packet radio, network interconnection and other ideas, and

3. the transfer would provide for sharing of the packet switching subnet among the private, government and public sectors under the aegis of a consortium in a legal and harmonius fashion, with minimal need for FCC control.

4. SPECIFIC PROPOSED PLAN FOR A PARTIAL TEST TRANSFER

REQUEST FOR INDUSTRY COMMENTS

To this point we have discussed a very general Transfer Plan and shall now consider the more specific steps required.

We believe that it is timely to consider reviewing the details of proposed test transfer with industry on a completely open basis. Unless the eventual arrangement is acceptable to one or more responsible organizations competent in packet switching, then the divestiture plan cannot serve its intended purpose. Any proposed arrangement must be fair to all parties; be workable and must lead to the desired end objective.

We recommend that the items and comments below be presented to industry for comment and feedback as an aid to planning. These are arranged in question and answer form to aid in collation of comments.

PURPOSE OF DISPOSITION

Why is the ARPANET important to DoD?

The ARPANET is a nucleating seed of a major potential national resource, whose continuing operation is deemed to be in the public interest.

What is the purpose of the proposed disposition?

The proposed disposition of the facilities is to accelerate the commercialization of technology developed by the Department of Defense, and to permit the provision of such services to the Department at comparable cost, wider availability and greater

effectiveness than the alternative arrangement of having to supply the same service under closely managed Department of Defense control.

<u>What is DoD's immediate interest?</u>

It is the interest of the Department of Defense to have such facilities continue in operation and continue to be made available for use by ARPA and other parts of the Department.

<u>What could the transfer accomplish?</u>

The Advanced Research Projects Agency (ARPA) of the Department of Defense, as operator and custodian of the ARPANET, seeks to transfer a portion of this network to better meet long term demands for growth of the network, improved versatility, survivability, reliability and usefulness to resource sharing. In detail, these objectives are:

<u>To meet the needs for system growth</u>. The ARPANET has grown to about a forty-seven node net in several years, and may grow at a similar rate for the near term. It is inappropriate for the DoD to sponsor the growth of any communications network beyond its own needs, especially if the private sector can accomplish the same end. Therefore, to respond to the pressures for growth on the network in both the number of connected sites and volume of traffic, the private sector is invited to share in the growth in lieu of open-ended governmental sponsorship.

<u>To improve system versatility</u>. As a DoD entity, the ARPANET is highly limited in the ease with which it can connect other governmental users and is precluded from adding purely commercial users. At present, the ARPANET facilities are limited to serving those with an ARPA contractual relationship and universities. Private organizations performing research in behalf of ARPA and government agencies may be served, but only those with a research requirement appropriate to ARPA's interests. Thus, the present rapidly growing community of interest represents only the "tip of the iceberg" in

the new demand for services. Such a demand cannot be filled without private participation. Private packet switching networks are coming, but in their early state can probably serve only groups of dedicated users.

Gain economy of scale. There are economies of scale in several aspects of communications networks. Better economy results if many users share a common resource than each providing his own under-utilized network. While there is the prospect that many packet networks will be built in the next decade, it will be in the public interest that these networks be able to interconnect to one another in a reasonably effective manner and that artificial barriers not be erected at the interface between these networks to prevent such flows whenever it is economically desirable to do so.

Improve system reliability. A small, thin network cannot be as reliable or handle as heavy peaks as a larger one with more redundant paths. Access to such larger facilities will be beneficial to ARPA. ARPA wishes to develop a rational set of rules to define and determine reliability for an overall network or for subnets. Since the government is relatively protected from the disciplinary forces of the marketplace, such rules for the protection of the overall network become mandatory.

Improve overall survivability for critical users. The larger and more highly interconnected a network, the more survivable it can be to enemy attack or natural disruptions. Thus, the ability of networks to interconnect with one another aids survivability. Of course, the problem is complicated as each would operate under independent and autonomous managements where the present ARPANET, or the divested form of the present ARPANET, is but one part of an eventual composite Combined Network. What is sought is a set of independent networks that can operate together.

Accelerate the development of resource sharing. The initial motivation for the ARPANET was, in part, to aid the development of large scale computer resource sharing. In keeping with this goal, ARPA wishes to encourage potential shared usage of facilities

between the ARPANET and any future firm wishing to acquire a portion of the ARPANET.

REQUEST FOR COMMENTS - OPERATIONS

Having described ARPA's goals and objectives, ARPA welcomes comments and suggestions that would help achieve these goals and is not limited by preconception or prejudgement. ARPA welcomes new private sector initiatives here and wishes to encourage all such efforts.

What is meant by "Combined Network?"

Definition of the Combined Network. The Combined Network consists of parts of the ARPANET devoted to providing non-experimental services plus one or more independent networks which are interconnected by one or more gateways. Each member of the Combined Network is a Combined *subnet*.

Will more than one Combined Subnet be Permitted?

Yes. ARPA is interested in considering responses from interested parties in helping to achieve the stated goals evolving toward development of a Combined Network comprised of the remaining ARPANET, plus new participants. While the ARPANET is composed of a homogeneous set of assets, e.g., IMPS, TIPS, leased line arrangements, only a minimum of coordinated management services connecting the components together must be centralized. Aside from the provision of some minimum overall management services for network control, the ARPANET could evolve into multiple ownership provided operation of the overall network is not jeopardized.

How can packets flow from one subnet to another?

The art of connecting different packet switching networks is still in a primitive state of development. Among the most care-

fully thought out proposals is that of V. Cerf and R. Kahn.*

While the Cerf/Kahn protocol appears to be a workable method of interconnection, even with entirely dissimilar networks, and goes far towards the solution of building the Combined Network, comments from industry are particularly desired.

While it would be highly desirable that the interconnection continue to be made at the packet level, provided this can be done without jeopardizing overall network performance, interconnection with gateways is clearly feasible at this time.

While no uniform packet level transnetwork protocol is presently defined, this arrangement will be regarded as an open possibility if a suitable proposal is made showing methods of insuring its workability.

<u>What does the ARPANET consist of?</u>

The total facilities of the ARPANET, including those under consideration for possible divestiture, consist of the elements shown in Appendix H. Equipment on this list are in "as is" state, and no statement, implied or otherwise, can be given as to condition or operating performance.

These elements are connected together with communication lines provided by common carriers. These lines are not the property of the ARPANET and are leased as shown.

<u>How much did the facilities cost?</u>

Equipment elements that might possibly be divested have been purchased over a several-year period. Appendices G, I and J describe a program used to estimate the present value based upon various costing and depreciation schedules. Whatever amounts are shown for

---

*V. Cerf and R. Kahn, op. cit., *IEEE Transactions on Communications*, to appear May 1974.

the convenience of the reader should not be misconstrued as being an implicit statement of the value of these facilities.

What is the 516 IMP, 316 IMP and TIP?

The 516 IMP. The work "IMP" refers to the unit described in [insert specification in Formal RFP] and includes a Honeywell DDP-516 minicomputer. Its characteristics are: sixteen-bit word size; .96 microsecond memory cycle; 16,000 words of memory; sixteen multiplex channels; and sixteen priority interrupts. The DDP-516 provides a throughput rate of about 850-kilobits per second as used in the ARPA network.

The 316 IMP. The 316 IMP is similar in operation to the Honeywell 516 described above, except that it is a lower cost unit, also made by Honeywell, and produces a throughput of 650-kilobits per second.

The TIP. The TIP is constructed of a Honeywell DDP-316 computer, plus an additional 12,000 words of memory and a special-purpose multi-line controller built by Bolt, Beranek and Newman.

If the ARPANET is divested, what minimum standards will be required?

The ARPANET has established through its various management services a procedure for testing the network and keeping daily records on the network's operations. Generally, the overall reliability of the system has been on the order of 98% up-time. The target minimum reliability is that the overall network be operational twenty-four hours per day, every day of the year.

What allowance should be considered for downtime?

In computing reliability it can be assumed that any individual IMP or TIP may be taken out of service as required by routine or emergency maintenance, provided that the fractional amount of time involved in all such maintenance shall not exceed five percent (5%) of all time, computed as follows:

Routine maintenance and program changes which interrupt service shall generally be restricted to a Scheduled Maintenance Period. The Scheduled Maintenance Period shall extend between 0100 and 0600, Eastern Standard Time.

Any failure which interrupts on-going computation from any TIP or IMP occurring outside a published Scheduled Maintenance Period as defined above shall be counted as Emergency Down Time. Emergency Down Time shall be measured from the first detection of failure until the failing unit is restored to full service. The duration of Emergency Down Time shall be multiplied by ten (10) when computing the time involved in maintenance discussed above.

Any transient failure which interrupts on-going computation from any TIP or IMP for three (3) minutes or less shall be counted as a thirty (30) minute Down Time failure. Any transient failure longer than three (3) minutes shall be considered as Emergency Down Time.

Failure of a single TIP input modem from the user shall count as a failure of one-tenth (1/10) its time duration in computing TIP statistics.

How would performance be reported?

The owner of any transferred facilities would be expected to provide failure statistics for each TIP and each IMP monthly and certify such reports as being correct. Signed copies of the performance reliability report would be sent to all active nodes on the combined network, and be used as the basis for reaching a subsequent decision for converting from a tentative to a final transfer of divested facility ownership.

What are the rights and duties for interconnection?

It would be expected that privilege would be granted to allow any IMP in the transferred part of the ARPANET, where desired, to be able to interconnect with any other IMP in the non-transferred part.

Such a connection right would be subject to the requirement that any such interconnection not jeopardize the reliability or performance of either node, or reduce the combined network reliability, and the incremental costs would be borne by the owner wishing interconnection. Requests for interconnection meeting this requirement would be granted and effected within 60 days, not counting delays involved in installation of required common carrier facilities.

Who would pay for the cost of leased lines used for interconnection?

Leased line or other communication arrangements would be negotiated by the nodes seeking interconnection. The share of costs borne by each node would be subject to negotiation.

Would all parties be treated the same?

Yes. All conditions and terms stated above would apply in an equal and reciprocal fashion to all participants in the combined network.

How would a prospective connecting subnetwork go about seeking ownership of a part of the network?

This of course would be controlled by allowable government contracting procedures, but in general, requests for proposals would be issued to encourage specific proposals, where each such proposal would indicate the particular elements sought together with a proposed timetable.

Will there be a trial period?

Each connected subnet would be given a 12-month test period to allow ARPANET and other members of the combined network an opportunity to stabilize operating and management problems before final acceptance is granted. During this 12-month transitional period, ARPANET representatives and other members of the combined network would work together and: review the technical, managerial and financial problems that require resolution and negotiate policy matters regarding future operations.

How will cross payments be made?

One of the key aspects of the proposed cooperative sharing arrangement is that a satisfactory mechanism for cross payments be developed. Details of one proposed arrangement are described in Appendix C, on formation of a common interest consortium of packet switching entities. One of the activities during the first year trial period is to test and refine the payments exchange mechanism. The participants of the combined network will, on occasion, use ARPANET facilities for switching packets in cases where the chosen route requires relay through non-transferred nodes. In such cases, the ARPANET should be reimbursed a per-packet fixed charge. Similarly, the transferred ARPANET nodes could use the transferred facilities to relay ARPA-originated/terminated traffic. In such cases, a reverse payment should be made upon an equivalent basis.

How much traffic will ARPANET continue to flow through its possibly transferred IMPS?

This is, of course, difficult to assess, but it seems evident that the traffic should be no less than is presently being carried. It is conceivable that ARPA could enter into contracts guaranteeing a minimum level of ARPA traffic that will equal or exceed either: the average of the six months preceding the transfer, or the average of the busiest six months in the year preceding transfer, whichever is greater.

RANGE OF COMMENTS DESIRED

To this point we have described how the transfer might be carried out. But this transfer cannot be done in a vacuum. It will require close cooperation between ARPA and other members of the possible combined network. To this end, comments are entertained from all interested parties.

What is sought is broad-based consensus of the most effective way of achieving the end objective, namely the long-term gradual conversion of a DoD-owned experimental facility to an operationally

integrated, but independently-owned network of networks providing excellent quality guaranteed service to fill ARPA's needs. But whatever alternative is suggested, it should also contain provisions to protect the government including return of facilities to ARPA with financial penalty if benchmark performance standards are not met. And, agreement by new owners of the transferred portions to interconnect to all other packet switching networks that meet agreed-upon standards, provided such other packet switching networks wish to engage in such interconnection.

In reviewing the comments, three test criteria should be:

1. Does the proposed arrangement guarantee that the operational performance of the ARPANET will be equal to or better than is presently experienced?

2. Will ARPA retain the freedom to regain the transferred portions if the trial does not work well?

3. Does the proposed approach avoid the present trajectory by which the nation will probably find itself with a set of packet switching networks that cannot talk to one another, preventing optimum reliability, load and resource sharing capability inherent in large packet networks.

IMPORTANCE OF INDUSTRY-GROUP ARRANGEMENTS

Basically the detailed plan proposed here is a way to guarantee a supply of milk without owning the cow. The idea is, "here is our cow which we could rent or sell to a buyer at a low price, but we insist that the buyer guarantee to take good care of this cow because we shall want it back if it isn't producing good quality milk."

As a matter of simple prudence, it is reasonable to expect that the would-be buyer demonstrate a knowledge of one end of the cow from the other. ARPA's interests would be further served if the buyer were willing to join his local dairy farm cooperative so that it can take on much of the burden of quality control. This not only reduces concern about having to worry whether the milk is fit to drink, it will also permit access to a greater supply of milk through the cooperative if needed. And, conversely,

it solves the problem of what to do with an excess of a highly perishable commodity which is occasionally in surplus.

Of course, there is no "farm cooperative" for packet switching. But, as described in Appendix C on the formation of a common interest consortium of packet switching entities, there are good reasons for ARPA to aid in establishing one.

The possible transfer should not hinge on the existence of a cooperative. Rather, the transfer is made much easier if the members of the combined network were working in a cooperative manner, as will be described in Appendix C.

APPENDIX ON LEGAL BACKGROUND ANALYSIS
(Appendix A)

The following appendix was prepared by Paul Goldstein to describe the legal considerations of divesting the ARPANET, regulatory considerations, and the alternatives to regulation.

Appendix A

LEGAL BACKGROUND ANALYSIS

by

PAUL GOLDSTEIN

Appendix A

LEGAL BACKGROUND ANALYSIS

PREFACE

Dispositions of public wealth have historically raised issues more pregnant and complex than those attending dispositions of private wealth. Policy, in the form of established legal rules, naturally shapes both dispositions, private and public. In the public disposition, however, policy occupies an added, special place: it is made. The sale of public lands is an early example, urban renewal a more modern one, of the disposition of public wealth to achieve specific goals--civilization of the frontiers or, more recently, of the cities. Complexity stems in part from the fact that the implications of any public disposition will invariably exceed its avowed objectives. Thus, large scale transfers may, by inundating supply, influence market prices, both short and long term; second order consequences usually include extended distributional effects.

Issues of government disposition become even more complex when the public wealth to be conveyed takes the form not just of realty or personalty, but of a functioning public institution that possesses many, if not all, the attributes of the firm. The complexity attending divestiture of public firms stems from the nature of the public firm--a firm all of whose operational decisions are vested in, or made the responsibility of, a governmental body--and of divestiture's consequences for the regulatory process, consequences flowing from the transfer to the private sector of the power to make some or all of the firm's operational decisions, decisions previously made in the public sector. Stated in its broadest terms--terms that will be refined in the course of this article--divestiture of the public firm, involving as it does the transfer of decisions from public to private hands, represents the

converse of the regulatory process, which involves the transfer of private decisions to public hands.

Because it is so thoroughly imbued with regulatory implications, the decision to divest a public firm deserves at least the level of attention paid the decision to regulate. The central most difficult task is determining which functions should remain under public control--regulated--which should be divested--deregulated--and the extent of divestiture for any component. The determination is complicated by the fact that public ownership may entail concessions not immediately available to private owners--reduced government rates on telephone lines, for example, or the governmental capability of continuous below marginal cost pricing--concessions likely to generate false signals respecting the prospects for the firm's success in competitive markets.

These and related considerations underlie the federal government's deepening evaluation of plans to divest the ARPANET, an experimental venture of the Advanced Research Projects Agency of the Department of Defense (ARPA) designed to test the efficiency, reliability and economy of a packet switched network for computer communications. Expansion of ARPANET's present structure and technology is expected to accelerate developments in the already burgeoning computer communications industry; indeed, the network may eventually form the nucleating seed of a major international and domestic data communications system.

The success of the ARPANET experiment, as measured by the satisfaction of present users and the increasing demands of prospective users for admission to the system, has raised the question of the institutional form that a fully operational, cost efficient network should take. Part I of this article considers, in the context of an analysis of the public firm generally, whether the decidedly commercial cost of the network's future role excludes the public firm as a fitting candidate for the network's continued management. Part II describes ARPANET's nature and origins and identifies an ideal set of characteristics for future operations. If, as concluded, full government control of network operations

through management of the system as a public firm would confine network performance to a point far short of the ideal stated in Part II, the relevant question becomes, to what extents should exercises of government control and the discipline of market forces influence the network's management for the ideal to be approached. This question is considered in succeeding sections: Part III examines regulation through government retention of certain network components, Part IV, direct regulation on the common carrier or public utility model. Part V summarizes the probable effects on network operations of largely unfettered markets and explores two market alternatives to regulatory techniques.

I. THE PUBLIC FIRM

TOWARD A REGULATORY CONCEPT OF THE PUBLIC FIRM

The behavior of all firms, private or public, regulated or unregulated, can be descr ed in terms of the operative decisions the firm routinely makes. With respect to the goods or services supplied by the firm, these decisions embrace price, quality, marketing techniques, materials and labor. The decisions also involve judgements respecting the level of investment to be committed to plant and research and development, and the rate of return to be derived from investment.[1]

While these decisions are common to all firms, the conditions under which they are made will vary with the character of the firm and with its regulatory setting. In the private firm, decisions are largely left to managers and boards of directors, to be made according to the objectives for the firm set by them or the firm's stockholders. Even for the private firm, however, there are some regulatory constraints on decision. Antitrust strictures, for example, may affect firm decisions respecting growth and caution against setting prices differentially or below average cost, no matter how profitable either strategy may appear. A pharmaceutical company's decisions on the quality of its drugs may be importantly confined by Food and Drug Administration rules and its marketing decisions limited by Federal Trade Commission rules on deceptive advertising; in these last two cases, the ambit for decision will be further circumscribed by the threat of private actions brought

---

[1] This catalogue of firm decisions is an abridgement and condensation of a more extensive, though summary, list set out in McKie, Regulation and the Free Market: The Problem of Boundaries, 1 Bell J. of Econ. & Man. Sci. 6, 7 (1970).

by injured consumers and competitors.

In the regulated industries--occupied by public utilities and common carriers--some decisions are, like the decisions made by private firms, lodged with private managers but hedged by general legal rules. Other decisions are preempted altogether. The commission charged with overseeing the regulated firm's operations may be empowered to determine the firm's overall revenue needs, and governmental determination of revenue needs will in turn affect other of the firm's decisions: the firm's managers will be dissuaded both from incurring expenses that they know the commission will disallow and from paring expenditures that, no matter how inefficiently applied, they expect the commission to tolerate. Also, while the regulated firm's revenues are prescribed in the aggregate, the aggregate figure is not the only source of limitation on the firm's pricing decisions. Thus, for example, under the Communications Act's requirement that carrier rates be "just and reasonable,"[2] the FCC enjoys the power to require alterations in tariffs that may in its judgement be too high or too low, whether measured by the cost to the carrier of providing the tariffed service or by the value of the service to the user. Finally, the regulated firm's decisions respecting capital expenditures or alterations in service are limited by the requirements of commission approval; accounting procedures, too, must be compatible with commission needs.

This comparison of private and regulated firms sheds some analytic light on the regulatory process generally and on the place of public firms in a regulated economy. It should be clear from the case of the private firm, and even more so from that of the regulated one, that the process of regulation involves little more than the removal from firm to government of part of the power to make some decisions and, in some instances, of the power to decide altogether. This suggests that differences in behavior between the private and the regulated firm are not of kind, but

---

[2] 47 USC Sec. 201 (b) (1970).

degree, the degree to which decisions have been transferred from the private to the public sector. This further suggests that the difference between private and regulated firms, on the one hand, and the public firm on the other is also importantly one of degree: in the case of the public firm, all operational decisions are governmentally made. Decisionmaking in public firms, as in private and regulated firms, will of course be influenced by consumer preference. Public firm decisions may additionally be affected by perceived voter preference.[3]

There is, to be sure, a difference of kind implicit in the regulatory process, a difference that is a function not of where decisions are made--in the private or public sector--but rather of the objectives toward which decisions are directed. The determination to regulate at any level implies a judgement that the performance, or, more accurately, the effects of performance, of the unregulated firm maximizing its internal economic objectives will not correspond with government's chosen social and political, as well as economic, objectives. Thus, the unregulated firm may consider that it serves its interests better by hoarding gold bullion than by purchasing pollution control equipment and that it would serve them better still by larding the campaign coffers of malleable legislators. At the least stringent level of regulation, laws establishing air quality standards, curtailing traffic in gold and proscribing corporate gifts to political campaigns are intended to confine private decisionmaking to a range more consonant with

---

[3] To the significant extent that public firms must compete with private firms in product, labor and capital markets, factors affecting public firm input decisions approximate those affecting private firm input decisions. While government's power of eminent domain might appear to give the public firm an edge on inputs unavailable to the private firm, the significance of the edge is limited by the facts that government must pay fair market value for property condemned and that private firms are increasingly coming to enjoy the substance if not always the form of eminent domain power.

perceived societal needs.[4] More significant, systemic, departures of private firm behavior from governmental objectives may call for the imposition of public utility or common carrier status.

The reasons for regulation are even more apparent at regulation's extreme, when the performance of private firms sufficiently departs from public needs to warrant the formation of public firms, either from scratch, as in the case of ARPANET, or through the nationalization of existing private firms. Wartime needs, if satisfied neither by the operation of free markets nor by the incremental process of regulation, represent at least the most dramatic predicate for the nationalization of private firms.

---

[4] It may be objected that the force of this distinction between public and private goals depends upon the view that firms pursuing private goals will be exclusively profit maximizing and that the distinction is blunted if, as has been argued, "planning," not profits, constitutes the objective of at least the larger firms. Compare J. Galbraith, The New Industrial State (1967) with W. Mueller, A Primer on Monopoly and Competition 160-175 (1970). See generally, G. Stocking & M. Watkins, Monopoly and Free Enterprise 491-529 (1951). See also, Hearings on Planning, Regulation, and Competition before the Subcomm. on Retailing, Distribution and Marketing Practices and the Subcomm. on Monopoly of the Senate Select Comm. on Small Business, 90th Cong. 1st Sess. 1-45 (1967) (debate between W. Adams, J. Galbraith, W. Mueller, and D. Turner).

However, it is not at all clear that in adopting planning as its goal, a firm is forsaking profits in any but the most limited sense. What is more likely is that it is shirking immediate profits for profits in the longer term. A firm or industry may, for example, voluntarily curtail its contaminant emissions, and suffer diminished present profits, in the hope that it will thus avoid public hostility and forestall future regulation that would cut more deeply into its operations. The force of the distinction --and, indeed, the case for regulation--might appear weakened by this last observation: to the extent that the firm plans with the objective of currying public and legislative favor, its operations can be expected to comport with public goals. The problem is, however, circular: absent regulation--or perhaps more important, the threat of regulation--the firm would have no incentive to plan in these directions. If anything complicates the distinction between private and public objectives, it is that the pursuit of private goals through unfettered markets is in this country itself a cardinal public goal.

Other functions--defense, the administration of justice are examples--are viewed as so central to the political system that the need for exclusive government control has been treated as self-evident.

Regulatory expedience, though a less obviously compelling reason than war or politics, also accounts for the formation of public firms. A commission that assumes control over a public utility's rate of return may soon find that the rate established has produced untoward effects on the utility's pricing and investment decisions; requiring the firm to relinquish these decisions, too, the commission may discover that, as a consequence, wrong decisions are being made on still other fronts, a phenomenon that McKie calls the "tar-baby effect."[5] At some point, full public control of the firm's decisions, which is to say full public proprietorship of the firm, may appear the most efficient solution. Efficiency, more than any other reason, perhaps accounts for a situation in which "it is not unusual to find that extensively regulated sectors of the economy succumb to complete socialization with government ownership and operation. In the last century, privately-owned roads, canals and bridges passed from regulated activities to government operations. The socialization of water supply and urban public transit is nearly complete."[6]

---

[5] "Any regulatory commission that tries to control these effects by regulating additional variables such as cost performance, executive salaries and prerequisites, choice of technical methods and rates of innovation, will quickly find its hopes to economize the means of regulation evaporating. As it extends further into the network of enterprise decisions it may discover that still other compensatory changes partly frustrate its efforts, and there are always more just over the horizon. Extension of control in response to perpetually escaping effects of earlier regulation may be called the 'tar-baby effect,' since it usually enmeshes the regulatory authority in a control effort of increasing complexity with little gain in efficiency but a growing feeling of frustration." McKie, Regulation and the Free Market: The Problem of Boundaries, 1 Bell J. of Econ. & Man. Sci. 6, 8-9 (1970).

[6] Jones, An Example of a Regulatory Alternative to Antitrust: New York Utilities in the Early Seventies, 73 Colum. L. Rev. 462, 465 (1973)

FORMING THE PUBLIC FIRM

If the market's failure to satisfy public needs is not the exclusive reason for the formation of public firms, it is at least a predominant one. The existence of three such public needs--reliability of service, equality of access, and innovation in techniques--underlies ARPA's decision initially to structure ARPANET as a public enterprise, and it may be helpful at this point to compare these needs generally with the nature of governmental response. This is not to suggest that needs of this sort are best met by public firms, but only that they are said to be by those whose word is law.[7] That the public firm is not the only, or necessarily the most efficient, means for satisfying compelling public needs should be evident from reflection on the performance of some public endeavors designed to achieve reliability, equality and innovation.

Reliability

Together with related historical and political factors, the need for a high degree of reliability is popularly perceived to underlie the decision to operate the functions of national defense as a public firm. While the need to internalize in government the power to make decisions respecting the uses of the defense establishment should be self-evident, it does not necessarily follow that the production and deployment of material and services are also best accomplished within the public sector; indeed, the military presently relies heavily on private firms for the production of material. That the military service function has largely been kept internal to the government can be ascribed to a factor not reproducible in the market, at least not since passage of the thirteenth amendment: government's power to compel

---

[7] For one comparative study, see Davies, The Efficiency of Public versus Private Firms, The Case of Australia's Two Airlines, 14 J.L. & Econ. 149 (1971).

its citizens to perform military or alternative service. Although this power might appear particularly attuned to the level of reliability represented by a captive, readily mobilized labor force, its exercise indicates only that the military is paying its servants less than they could command in the marketplace. Recent moves to abolish the draft and to replace it with schedules of compensation more nearly enjoying parity with labor's market value suggest that the conscription power is not a prerequisite to reliability and security.

Equality

The problem of equality in access arises in its most graphic form when the cost of vital services for which demand is relatively inelastic--municipal transit and postal service are two--exceeds what an important segment of the public can reasonably be expected to pay. To avoid undesired distributional effects, government could permit provision of the needed services on a competitive basis and achieve equalization through direct payments to the poor either in cash or in vouchers, as is done with food stamps. Alternatively, government could channel its subsidy directly to the private entrepreneur, requiring in return pricing that, though uniform, is at a level the poor could afford. Government could also give the private enterprise a wide latitude for price discrimination, prohibiting resale by low-price buyers and exacting as a condition for its permission the firm's agreement to price services for the poor at an affordable level, below the firm's average and even marginal cost; presumably, the firm would make up its losses in these markets by capturing consumer surplus in more affluent markets.

The first two of these approaches are generally shunned because government seems to prefer covert to overt subsidies. While the third approach roughly approximates the one employed in the differential pricing of business and residential telephone service, there is no evidence that residential service is provided at less than marginal cost and, in any event, the latitude allowed

has not been sufficiently broad to provoke undesired political reaction.[8] The governmental solution, motivated by the need for both equality as actually enjoyed and equality as perceived, has in many areas been the public firm, setting a single below cost price for its services, subsidizing its activity covertly from tax revenues.

Innovation

The formation of public firms may also be prompted by the existence of areas of significant technological need, the resolution of which will not, for one reason or another, be achieved in the private sector. The very magnitude of the problem to be solved may be thought a sufficient condition to goad the profit-seeking firm to its solution, particularly if the firm is abetted by the promise of patent protection for its discovery. Yet, the anticipated profits to be derived from marketing a discovery do not necessarily correspond with the magnitude of its need, a phenonmenon that may go far to explain the poverty of innovation in instructional materials for public and private schooling. At the same time, elements of risk, associated with any research and development venture, may for the private firm render the opportunity costs of research expenditures unbearably high. Finally, the patent law, never a particularly efficient system for encouraging needed innovation, has in recent years revealed itself to be an increasingly creaky device, its promise hedged on all corners. It is in these areas of great unmet needs, where the calculus of anticipated profits, risk and patent protection weighs against the private commitment of resources to innovation, that more direct government intervention becomes appropriate. Intervention may take the form of direct subsidy, as in ARPA's

---

[8] At the same time, significant income-based disparities in access have been successfully avoided in the pricing of residential telephone services. See, Bureau of the Census, Current Population Characteristics, Characteristics of Households with Telephones, Table I (Series P-20, No. 46, 1965).

dramatically successful program of support for research in advanced computer capabilities, or it may take the form of a public innovative enterprise like ARPANET.

DISSOLVING THE PUBLIC FIRM

Because it is an instance, not an exception, of government regulation, the public firm is subject to many of the same stresses that affect regulation generally. Thus, just as for regulated private firms the tug of the marketplace may first be felt in assertions that the firms will more efficiently achieve relevant public goals without a particular legal rule than with it, so in the case of public firms, the demonstrated superiority of private firms in reaching public goals may call for the transfer of all or parts of the firm from the public to the private sector. The mission-oriented enterprise, like ARPANET, once having marshalled resources to initiate major change, may, if called on to market the services it has developed, be expected quickly to fall into a pattern of resisting change, a particularly undesirable posture in fields where continued flexibility and invention is essential. ARPANET's nature, objectives and underlying technology, described in the next section, strongly suggest that an optimally functioning network will have to be highly responsive to the needs of users in private firms, academic institutions and government agencies and that, to a significant extent, responsiveness will require the commitment of resources to incremental innovation.

This informing need, responsiveness to consumer demand, particularly as responsiveness takes the form of innovation directed toward demand, suggests the public firm's incapacity to provide the desired kind and level of services. Lacking a price mechanism sensitive to competitive forces, lacking any basis for receiving accurate signals as to performance and consumer needs, lacking any spur to business-oriented innovation or any road map identifying the proper direction for innovation to take, the public firm seems poorly placed to operate an optimally functioning network. This is not to say that the public firm's structure

for decision-making could not, with some work, be fashioned to simulate the more responsive decisional structure possessed by private, competitive firms--indeed it could. The point, rather, is that if a structure disciplined by the market would function best, then it would seem more efficient to bypass simulation and get the real thing.

In assessing the most efficient means for government to shed the public firm, it will be important to keep in mind that although the transfer of public firms to private and competitive markets is commonly characterized as divestiture, it may be both more accurate and helpful to treat the transaction not as a sale but as an instance of deregulation. Just as the regulatory loop can be run forward, from the largely unregulated private firm, to the regulated firm, to the public firm, so it can be run in reverse; shedding some of its components, retaining others, the public firm can be introduced into the market as a private firm regulated to varying degrees. This point suggests that the decision to divest involves judgements respecting not only the extent to which previously regulated components should be deregulated but also, by implication, the extent to which the firm's behavior should remain regulated, taking into account the effect on regulated components of the newly deregulated components.

II. THE NATURE AND OBJECTIVES OF THE FIRM

Under present, generally prevailing conditions, a computer center, if it wishes to use distantly located data files or software, must first reproduce the data or programs internally. As elsewhere, this redundancy stems from inefficiencies in communication, specifically from the application of existing communications systems to unanticipated and largely incompatible computer communications uses: quality of long-haul service over telegraph and voice grade communication lines is far below what computer users can reasonably be expected to tolerate, and the cost of national interconnection through leased lines or dial-up facilities is prohibitively high. Widespread differences in local facilities also impede fluent computer communications: hardware, programs and formats at one site may be incompatible--and hence uncommunicative--with their counterparts at a distant site from which information is desired.

The central objective of packet communication networks is to reverse these inefficiencies and capture the significant, unrealized scale economies represented by multiple, widely distributed use of a single computer resource: hardware, software and data which now must be replicated to be used at distant sites would be directly accessible to any system in the network, wherever located. The informing innovation of network packet technology lies in its conversion of existing communication modes to efficient communication use. Added innovation has focused on resolving the second need, inter-system compatibility.

Linking a number of autonomous, nationally dispersed computer centers, packet communications networks would facilitate interactive communications between any two systems within the network.

Network operation would rely upon a geographically distributed set of switching centers. Each center would be hooked up through leased landlines, or through microwave or satellite, to a small number--subset--of other centers; centers within any subset would be linked to centers in other subsets with the result that, taken together, the centers would form a fully distributed, richly interwoven network enabling communication, through linked centers, between any two points in the system. Because several linked paths would be available between any two centers, a high degree of reliability would be assured.[9]

Situated at each switching center would be technology functionally similar to that now employed at centers in the ARPANET: an Interface Message Processor (IMP)--a small, general purpose computer designed to route messages (in the form of packets of bits), check for errors and provide links to the network's computer resources (HOST's). TIPS--terminal IMPs performing all IMP functions and also interfacing up to 64 individual terminals within the network--are also scattered throughout the ARPANET.

As a goal, future networks would seek to offer a wide variety of services tailored to meet the information processing needs of the broadest range of users. Access between any two points in the world would be possible, at high data rates and with communications and maintenance costs, errors and dealy, low in comparison to other system costs. The system would be fully distributed and autonomous so that malfunction or disaster at any node need not affect the rest of the system; users could enjoy sufficient security to exchange messages with only minimal concern for sabotage or other interference by unauthorized oursiders. These are, to be sure, goals and not

---

[9] This description of ARPANET and its background is drawn from Roberts & Wessler, Computer Network Development to Achieve Resource Sharing, 36 AFIPS Conference Proceedings, 1970 Spring Joint Computer Conference 543 (1970), which contains a good general discussion of the network. Other, succeeding, papers in the same volume present more specific studies of aspects of network operation.

present reality, but they do suggest the contours of an ideal toward which the system's operation might be directed.[10]

It was in response to long-range goals of this sort, as well as to short-range interests in sharing ARPA-owned or funded resources more effectively, that ARPA initiated the ARPANET experiment in September, 1969. In the experiment's first phase, the network interconnected 14 sites, primarily university and non-profit research centers, each involved in ARPA-supported research, widely scattered across the country. The second phase, which began in 1970, involved the interconnection of additional sites engaged in a broader range of research activity. However tempting entry into a commercial service operation might at any point have appeared, ARPA, chartered as a research, not a service, agency avoided these potentially lucrative markets.

Largely because ARPA's mission in designing the ARPANET was not to develop an ideally, or even adequately, functioning

---

[10] Recognition that this is an optimum, not likely to be realized in practice, does not necessarily imply that all steps taken in the direction of attaining the optimum will place the network in a better position than would have obtained had the steps not been taken. By way of comparison, economics' general theory of second best states that when one or more of a set of optimal conditions are not fulfilled, there is no reason to believe that the optimum can be approached by fulfilling or approximating more closely more of the conditions rather than fewer. See, e.g., Lipsey & Lancaster, The General Theory of Second Best, 24 Rev. Econ. Studies 11 (1956). Whether or not there is a technological counterpart of the general economic theory of second best, any such theory would appear inapplicable to the ARPANET which, as a service institution comprised of many discretely operative components, would seem effectively placed to enjoy incremental advances in internal efficiency.

This is not to say, however, that steps toward the network's optimum will not produce disproportionate second order effects--both technological and economic--generally, or even to say that the network's operation at its own technological optimum will more likely tend to advance social welfare than operation short of the optimum. Thus, it is entirely possible that a system enjoying far fewer internal efficiencies than the one proposed will be preferable from an overall welfare perspective, as measured by allocative effects on other sectors of the economy. Analysis at this level, however critical, is beyond the scope of this paper, and when the term "welfare is employed, it is intended only to represent the limited public interest in a system working at the described technical optimum.

commercial network but rather was confined to exploring ways in which the technology for such a network might most efficiently be assembled, the ARPANET as now structured lies far from the network's long-range, commercially based goals. Thus, the network's present topology merely traces the location of ARPA contractors and grantees and does not follow the pattern of commercial computer use in this country. New York, Chicago, Dallas, and Houston are not represented, and many more nodes--Los Angeles, San Francisco, Boston, Detroit, Seattle are some--would have to be added before commercial computing centers would have sufficient access to network resources to make the network a paying and fully efficient proposition. Also, the IMP and TIP equipment presently employed--Honeywell DDP 516 and 316 computers--represent technology that is now 10 years old and suffers important limitations on memory capacity, obsolete architecture and relatively expensive components.

The gap between ARPANET's subsidized and highly experimental present and its commercially profitable well-functioning future can be expressed in terms of traditional firm decisions. In the ARPANET today, research and development focused on quality forms the predominant objective of firm decision-making. Decisions respecting price, marketing techniques, materials and labor for network services are almost totally absent; decisions respecting rate of return to be derived from investment are made, if at all, only in the most abstract sense. All of these characteristic firm decisions--decisions other than those embracing research and development--can, however, be said to exist in embryo, awaiting full network development in either the public or private sector.

The gap between the network's present and its future can also be described functionally. Under this approach, ARPANET's future operations can be divided into (a) the provision of computer communications services on a commercial basis, and (b) research and development focused on, first, overall basal network advances and, second, on improvements in resource sharing technology. Given ARPA's posture as a research agency, the service function

would appear to be best divested. Given the Agency's research posture, and the market's probable inability to stimulate innovation along the first, basal lines, it would seem appropriate to retain this function in ARPA. Innovation of the second, incremental sort, however, because it must be directly responsive to the needs of network users, would, on balance, seem properly lodged with the service function.

Obviously, the bulk of firm decisions--those respecting price, quality, marketing, materials, labor, rate of return--are connected with the service and service-related innovation functions and would naturally flow with divestiture of these functions. Divestiture might, as noted, be to another public firm--one already existing, as, say, the Postal Service, or one to be established. If, however, for reasons already given,[11] private firms appear best placed to receive the divested service functions and their connected firms decisions, some further questions arise: can market decisions privately made be relied on for the maintenance of adequate quality of network service? If not, through what techniques should private decision be curbed: by retention in ARPA of key quality decisions? By direct FCC regulation? Or, by less direct means? These questions are considered in the sections that follow.

---

[11] See *supra*, pp. A-12-A-13.

III. REGULATION BY RETENTION

As presently structured, ARPANET is a vertically integrated public firm which, though it has contracted with private firms for the performance of some functions, has retained control of all. While the public interest may press for ARPANET's disintegration and for the transfer to private firms of institutional parts and functions, the public welfare may also command the retention of some components in the public firm or in government generally. Thus, if it is felt that, left to the discretion of private firms, the quality of network services will deteriorate to a less than acceptable level, ARPA may decide to retain institutional functions incorporating critical quality decisions--basic system programming functions, for example. Or, if perpetual private ownership of network components is seen as too chancy a route, the agency could impose a specific time limitation on the transfer, as in typical leasehold transactions. Alternatively, ARPA could hedge its grants with performance criteria, requiring as a condition of continued private ownership the provision of service at some specified level of quality.

THE GENERAL SETTING

Although there are important differences between the sale of government resources and divestiture of the public firm, it may be helpful for comparative purposes to consider two well-developed instances of government transfer of resources--the conveyance of public lands and the grant of licenses for use of the electro-

magnetic spectrum.[12]

The Public Lands Analogy

The United States government has disposed of the bulk of its land in hopes of achieving objectives that could not as well be met if the land were retained. In some cases, the purposes of the government grant were general: to stimulate the settlement of sparsely populated areas and to encourage private ownership of land. In other cases, the purposes were more spcific: to encourage the development of railroads, for instance, or highways and schools.[13] The federal grants have commonly been made in fee simple absolute with only the most narrow and immediate strings attached: duration of ownership has been perpetual, save of course for the always prevalent prospect of eminent domain; and the conditions imposed on the grant have rarely been burdensome--development and cultivation of the ceded land for three years under the Homestead Act, for example.[14]

These characteristics of public lands policy--perpetual ownership encumbered by few conditions--seem particularly fitting for divestiture of ARPANET's components. To begin with, the general argument for perpetuity is especially persuasive in the case of the network: "the market tends to operate more efficiently when the time-tenure of the property interest is of long duration, since predictions about the usable life of specialized

---

[12] Both instances are closely and imaginatively explored, the first by analogy, the second directly, in DeVany, Eckert, Meyers, O'Hara & Scott, A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic Engineering Study, 21 Stan. L. Rev. 1499 (1969).

[13] See generally, B. Hibbard, A History of the Public Land Policies (1939); Davidson, Government Role in the Economy, 48 J. Urban L. 1, 3-4 (1970).

[14] 43 USC Sec. 164 (1970). Under the original act, 12 Stat. 392 (1862), the required term was five years.

capital equipment investments are thereby made less critical"[15] --although, to be sure, a limited but specified term would increase calculability. The network owner for whom loss of the operating franchise is a relatively imminent prospect, will be less disposed to make needed capital and research and development expenditures than one whose ownership is perpetual, particularly since the short-term owner can expect that loss of his franchise will be attended by sharp reductions in value of plant, and of knowhow.[16] The same factors, together with the need for flexibility in a

---

[15] DeVany, Eckert, Meyers, O'Hara & Scott, A Property System for Market Allocation of the Electromagnetic Spectrum: A Legal-Economic Engineering Study, 21 Stan. L. Rev. 1499, 1531 (1969)

[16] There are two arguments for the position that a renewal system will exert a contrary, pro-innovation effect or, at the least, will be no less conducive to innovation than a scheme of perpetual ownership. First, if renewal is made to depend, explicitly or implicitly, upon some level of commitment to innovation, the desire for renewal can be expected to goad the firm to undertake a desirable amount of innovation. This assumes, however, that an administrative agency can safely prescribe level of commitment with a fair degree of certainty--an unlikely enterprise given the unpredictable nature of innovation--for, to the extent that the prospective standard is uncertain, the firm will discount the value of renewal by the risk of non-renewal. And, to the risk factor must be added the transaction costs of the renewal process. The argument assumes, too, that both the direction and level of innovation prescribed by the agency charged with administering the renewal program will be at least as desirable as the direction and level identified by consumer decisions in the marketplace.

Second, it may be argued that the firm whose license is not renewed is, in any event, in no worse a position than the firm which, enjoying a position of perpetual ownership, decides to sell off its assets. The problem here stems from the significant extent to which the value of a firm's assets will lie in the relative modernity of the firm's software. An agency decision that the firm's programs possess an insufficient degree of innovative thrust to qualify for renewal can be expected to depreciate the assets in the eyes of a prospective purchaser which, to gain agency approval for its operation, would probably be inclined to proffer an entirely new system or, at least, one that bore few of the characteristics of its predecessors'.

vigorously competitive setting, would appear to counsel against imposing serious restrictions on permissible use.[17]

The Spectrum Analogy

Demonstrated, widespread inefficiencies in FCC management of the electromagnetic spectrum under which portions of the spectrum are allocated to private users on a durationally limited and heavily conditioned basis weigh against the adoption of a similar approach in the ARPANET divestiture. Moreover, persuasive arguments, both for placing spectrum management on a market footing[18] and for designing experiments to test the market hypothesis,[19] share a view of the spectrum resource that is particularly applicable to ARPANET. Acknowledging that spectrum is a resource, this view maintains that, "While it is true that the Government appropriated the resource in 1927, it did so not on the ground that the Government was entitled to the wealth created by use of the resource, but rather on the ground that regulation was necessary for the resource to be useful at all."[20] The relevant point is that ARPANET, like government management of the spectrum, originated in a context in which the market alone would have produced undesired results. In the case of the spectrum, unregulated uses would have overlapped to an intolerable degree; in the case of packet switching, technological and regulatory uncertainties would

---

[17] See supra, pp. A-12-A-13.

[18] See generally, H. Levin, The Invisible Resource: Use and Regulation of the Radio Spectrum (1971); Coase, The Federal Communications Commission, 2 J. L. & Econ. 1 (1959); cf. President's Task Force on Communications Policy, Final Report ch. 8 at 28-40 (1968).

[19] See DeVany, Eckert, Meyers, O'Hara & Scott, A Property System for Allocation of the Electromagnetic Spectrum: A Legal-Economic Engineering Study, 21 Stan. L. Rev. 1499 (1969).

[20] See DeVany, Eckert, Meyers, O'Hara & Scott, A Property System for Allocation of the Electromagnetic Spectrum: A Legal-Economic Engineering Study, 21 Stan. L. Rev. 1499, 1531 (1969)

have discouraged any private firm from making the necessary investment in plant and research and development. Once it is shown that the original market dilemma can be meliorated--as in the case of spectrum--or that it has disappeared entirely--with ARPANET's production of the needed basal innovation--largely unconstrained divestiture to the private sector becomes timely.

Guidelines for Divestiture

All of this suggests two principles that could guide the disintegration and parcelling out of the ARPANET. First, components of the network could be made available to bidders on a basis that will enhance innovation and flexibility within their firms; this means, specifically, ownership unlimited in time and bounded only by the most slender, expedient conditions. Second, if the market is to be relied on to encourage the most efficient use of the network's components, then bidders for these components must be treated on the terms most consonant with maintenance of competitive conditions; simply, no single bidder should be given from ARPANET assets a competitive advantage not available to all others on equal terms. The second principle bears on the question, how the network is to be divested, and the first on the question, how much. It is to the question of how that discussion now turns.

THE ASSETS AND THEIR DIVESTITURE

ARPANET possesses two institutional elements of value to private bidders, one easily appropriable, the other less so. The first, appropriable, class of assets consists of hardware--IMPS, TIPs and interfacing equipment situated at the IMPS for connection with the hosts--and of software--undisclosed proprietary data in programs essential to operation of the system.[21] The second, less

[21] Omitted from this list of assets are the main computers situated at each HOST which, under varying arrangements, have been provided to the HOSTS by ARPA. The disposition of these facilities has been excluded from this study.

appropriable, class consists of the network's going value which, for present purposes, can be described as a congeries giving its possessor some competitive advantage in making those operational decisions central to any firm, private or public.[22] Transfers of assets in the first class can be viewed as involving the products of decisions already made--investment decisions respecting hardware and innovation. Transfers in the second class involve instead the power to make decisions in the sense that some or all of the decision-making powers divested are, for successful bidders, enhanced in a way that they are not for unsuccessful bidders and non-bidders. This is simply to say that if, as between A and B, competitors in the packet switching business, A receives ARPANET's going concern value and B does not, A will with respect to some or all of its operational decisions--pricing and marketing, for instance--enjoy advantages that B will not.

The Appropriable Assets

The decision whether ARPA should retain existing network hardware--TIPS, IMPS and interfacing equipment--or whether the hardware should be divested and, if so, on what terms, calls for some relatively straightforward judgements respecting desired levels of barriers to entry and of innovation. Thus, if relatively free entry is desired, ARPA could retain title to the hardware and lease the needed equipment to successful bidders on terms less forbidding than those entailed by either initial capital outlay or indebtedness. Alternatively, if some hurdle to entry is percieved as appropriate--possibly to separate the serious and resourceful entrepreneurs from those that are undercapitalized--then outright sale of the present stock of hardware may prove to be a desirable screening technique. And ARPA may, under either the sale or lease approach, employ the price mechanism to modify the conditions for hardware innovation; by adjusting hardware prices up or down, the agency can increase or decrease the relative desirability to users

[22] See supra, p. A-4.

of purchasing, or committing research and development resources to, network hardware.

Technical knowhow concerning the network's most efficient operation under present conditions might appear generically indistinguishable from ARPANET's hardware assets. In fact, it is vitally different: in some instances the knowhow is completely inappropriable--because already in the public domain--while in others it is too fully appropriable--and, sequestered by private ARPANET contractors, is unavailable even to ARPA. In the first, inappropriable, class of knowhow, there is, of course, nothing to be divested, all the information involved being freely and publicly available. The second class, on the other hand, raises a number of serious questions for divestiture policy. Should ARPA let this proprietary data remain in their present hands, for the exclusive use of private contractors? Should compulsory licensing at specified rates be required? Should ARPA appropriate the proprietary data to itself and, if so, should it license their use or should it inject the data into the public domain as it has done with other network knowhow?

However the other questions are resolved, it seems clear that the questions whether network proprietary data are to be left to the exclusive use of ARPANET contractors who become network bidders should be answered in the negative. To allow present contractors who become future bidders to retain as their own proprietary data developed in the course of ARPANET's developmental stage would confer on these firms a competitive advantage over entrants not occupying this privileged position and possibly deter entry by disadvantaged bidders altogether. While for reasons already given, some barriers to entry may be appropriate, this will be the case only if the height of the barriers is uniform.

It can of course be argued that present contractors who become network participants may be expected to behave like prudent patent and trade secret proprietors generally, licensing the use of sequestered information to others at the profit-maximizing price; that the network information owner is a vertically integrated producer-supplier gives it no reason to discriminate

against non-integrated suppliers by entirely refusing them access to the information product. Under this argument, the question then becomes one of the price charged. The general substitutability of this sort of information indicates that the price would not be one from which much in the way of monopoly profits could be extracted.

Perhaps because it imputes rational economic behavior to network managers, and because it ignores widespread but erroneous assumption respecting the anticompetitive behavior of vertically integrated firms, this argument appears to make considerable sense.[23] Moreover, there would seem to be no significant economies of integration--no internal savings of external transaction costs--peculiarly attributable to transfers of proprietary data and, consequently, no reason for the integrated network to favor its own branches to the exclusion of outside firms.[24]

What may make a difference in terms of long run monopoly effects is not so much the fact that possession of proprietary data will give network contractors a competitive edge as the fact that, because the underlying research and development was government financed, the edge was obtained risklessly. Lacking the need to finance past investment from current data revenues, the advantaged contractors may be more inclined to hold the data off the market, particularly if they believe that the exclusionary tactic, together with their vertically integrated posture, will pose significant barriers to entry.[25]

---

[23] See generally, Bork & Bowman, The Crisis in Antitrust, 65 Colum. L. Rev. 363, 366-368 (1965).

[24] See Allen, Vertical Integration and Market Foreclosure: The Case of Cement and Concrete, 14 J. L. & Econ. 251, 255-272 (1971). A network developer of proprietary data may, however, respond to the general danger that, through leakage, his trade secrets will lose their secrecy and, consequently, their legal protectability. To the extent that leakage appears less likely to occur in the internal transfer of data than through their licensing to outsiders, this factor may be seen to produce one integration economy.

[25] Compare Blake & Jones, In Defense of Antitrust, 65 Colum. L. Rev. 377, 392 (1965).

The Less Appropriable Assets

Whatever the market value of ARPANET's appropriable, hardware and software, assets, it is the less appropriable assets that probably possess the greatest attraction for prospective network bidders. This is particularly ironic since, once hardware and software are excluded, there is little or nothing left in the ARPANET inventory that can be characterized as assets in traditional terms. The significant research and development that has brought ARPANET from an idea to an operational entity is, with the relatively limited exception of what is being withheld by private contractors, all in the public domain. "Going concern value" is scarcely discernible, particularly because, if the network is structured along competitive lines, there will be no single firm that can properly call itself a successor to ARPANET. What is left is a customer base and goodwill of a highly fractionated sort, far less, say, than would be involved in the sale of assets of a popular periodical.

The customer base component of the ARPANET inventory has two aspects. The first derives from the needs of network users in quality and reliability of service. These needs, which will be particularly pressing during the period of the network's transition from public to private ownership, might be met by a program of ARPA endorsement, with customers naturally drawn to those firms that bear some imprimatur of ARPANET affiliation. Yet, while proprietary data can be effectively subjected to licensing schemes, reputation cannot be so easily marketed. The benefits associated with trademark licensing, popularly thought to serve a reputational guarantee function, are largely unavailable in this context. And, in any event, introduction of a franchising system, even if it could be mounted efficiently, might well contradict demonstrated interests in genuine competition.

Because of the difficulties and imperfections associated with a trademark licensing scheme, it can be expected that present ARPANET contractors who successfully bid for a share of the network will, because of the history of their association, attract the bulk

of prospective users, particularly during the critical interim period. This means, of course, that present contractors will, by reason of their past work for ARPANET, enjoy a competitive advantage with respect to new entrants not unlike the one they would enjoy were they permitted to retain proprietary data. Here, however, it would seem wasteful, and not at all consonant with the needs of users during the interim period, to achieve uniformity in barriers to entry by requiring present contractors to disqualify themselves as bidders and to set parity at the lowest common denominator of performance.

IV. IRECT REGULATION

The delivery of telecommunications is in this country left to private enterprise. Elsewhere in the world, these services are commonly provided by government through public firms.[26] The international comparison underscores the boldness of American policy and the thrust of its governing presumption: wherever feasible, the provision of goods and services, no matter how vital, should be left to private firms. Both the policy and presumption permit a corollary: wherever feasible, private firms should be allowed to make their operational decisions unconstrained by government regulation. In the case of the ARPANET, this means that, though presently an embryonic public firm, there is every reason for it not to develop as such. It means, further, that if the network is handed over to private firms, government control of firm decisions should be kept to the necessary minimum.

The general presumption against regulation gains compelling force from some historical and economic factors surrounding communications regulation generally and network conditions specifically.[27] If the divested ARPANET is to be regulated at all, regulation is most likely to come from the FCC which in the area of telecommunications characteristically works on an all or nothing basis: if a firm is regulated it is as a common carrier, with application to telecommunications common carriers like the

---

[26] Several of the Canadian provinces stand with the United States as the important exception to this general approach.

[27] See Posner, Natural Monopoly and its Regulation, 21 Stan. L. Rev. 548, 592-620 (1969), for a generally balanced assessment of the costs and benefits associated with regulation of public utilities and common carriers.

the Bell System and Western Union.[28] Little if any room is left for incremental regulation, tailormade to fit the needs of the regulated form, room that is vitally needed if the emerging network is to adapt effectively to market conditions.

FCC control of the budding network seems inappropriate for another reason. Often inhospitable to newly emerging industries and technologies that appear to threaten the economic security of entrenched, already regulated firms, the Commission has been known to regulate prospective entrants to a point at which entry itself is all but impossible. This concern may be softened somewhat by hindsight: the protective stance has most frequently been taken in the broadcast context, in the form, for example, of rebuffs to CATV's perceived assaults on the integrity of VHF operations;[29] defenses on the common carrier side have not in recent years been nearly so high.[30]

---

[28] The prospect that regulation will, or can, be structured under Title III, "Special Provisions Relating to Radio," appears sufficiently unlikely not to warrant consideration here.

[29] See generally, Goldstein, Information Systems and the Role of Law: Some Prospects, 25 Stan. L. Rev. 449, 461-470 (1973). Similarly, the prospects for UHF's growth were early stunted by the Commission's failure to put the new industry in a position to compete with the already established UHF system. See generally, Note, The Darkened Channels: UHF Television and the FCC, 75 Harv. L. Rev. 1578 (1962); Webbink, The Impact of UHF Promotion: The All-Channel Television Receiver Law, 34 L. & Contemp. Prob. 535 (1969).

[30] For example, in Microwave Communications, Inc., 18 FCC 2d 953 (1969), petitions for reconsideration denied, 21 FCC 2d 190 (1970), and the ensuing rulemaking, First Report and Order in Docket No. 18920, 29 FCC 2d 870 (1971), the Commission granted free entry to specialized carriers which, in competition with Bell and Western Union, proposed to offer point-to-point microwave relay services specially tailored to meet the needs of the business and data transmission communities. In neither proceeding was the Commission persuaded by the existing carriers' argument that entry would enable the specialized carriers to reap the rewards available in highly profitable markets, an argument rooted in regulated industries' common practice of differential pricing, employing supranormal profits from one area to subsidize average cost. While, on balance, systems of cross-subsidy pricing generally may be demonstrated to do more harm than good, the Commission

REGULATION: CONDITIONS AND CONSEQUENCES

Together with these other considerations, there are two particularly salient reasons for FCC abstention from network regulation. First, the market to be occupied by the divested network possesses few if any of the natural monopoly contours that traditionally justify imposition of public utility or common carrier treatment. Second, in an area critical to ARPANET's success--innovation--the performance of firms under regulatory constraint has been seriously questioned.

Natural Monopoly

A natural monopoly is said to exist in markets where demand can most efficiently be met by a single firm. The cost efficiency of the single firm in natural monopoly markets is a function of significant economies of scale, unit costs declining as production scale increases, and of relative capital intensity,

---

skirted the basic welfare question and rested its decision and order instead on the view that to permit entry would not only promote satisfaction of presently unmet needs but would also spur the existing common carriers to provide improved, more competitive service in the areas to be served by the new, specialized carriers.

For the cross-subsidizer, the obvious competitive response to a specialized carrier's cream-skimming is the one subsequently made by Bell and Western Union--dropping prices in the formerly highly profitable markets to meet or undercut those of the newcomer, subsidizing these drops through increased prices elsewhere. Compare Baumol & Walton, Full Costing, Competition and Regulatory Practice, 82 Yale L. J. 639 (1973) with Noll & Rivlin Regulating Prices in Competitive Markets, 82 Yale L. J. 1426 (1973).

Particularly if, as has been shown, competition will best serve the interests of network users, there is every reason for the MCI rationale to apply with at least equal force to answer any charge that a divested ARPANET would improperly be skimming the cream from established common carrier operations.

with the ratio of fixed to variable costs being continually high.[31] To the extent that these factors are present, a natural monopoly condition exists and a single firm is recommended; regulation of the firm, as a public utility or common carrier, is in turn seen as required to prevent the abuses popularly associated with monopolies.

The market to be occupied by the divested ARPANET appears to possess none of the characteristics of natural monopoly in a sufficient degree to warrant divestiture to a single firm. Two classes of capital outlay will be essential to the network's operation: a national transmission system consisting of telephone lines, microwave, and communications satellites; and terminal to network interface hardware and software. While the capital costs are high in both classes, the critical point for the ARPANET is that the necessary capital outlays have been and will continue to be made outside the network industry. The transmission facilities to be employed by the network are either already in place--as in the case of the Bell System--or are being developed by non-network firms--specialized common carriers, for example, or domestic satellite entrepreneurs.[32] Hardware and software costs, while

---

[31] Essentiality to the community of the service in question has been cited as a third factor indicative of natural monopoly conditions. Irwin, The Computer Utility: Competition or Regulation?, 76 Yale L. J. 1299, 1313 (1967). This factor appears, however, to be not so much a predicate for natural monopoly as a description of some of the services provided by some public utilities and common carriers. A number of essential services and products--health care and food are examples--are provided under truly competitive conditions, while many of the services provided under natural monopoly conditions, many of Bell's regulated offerings, for example, can only be characterized as nonessential.

[32] One result to be expected from the FCC's MCI decision, and the ensuing rulemaking, see supra, n. 30, is the proliferation of special function transmission systems throughout the country, frequently existing side-by-side. Especially as augmented by domestic satellite transmission capabilities, see generally, Mathison & Walker, Regulatory and Economic Issues in Computer Communications, 60 Proceedings of the IEEE 1254, 1264-1268 (1972), the future transmission picture reveals a multiplicity

they may be incurred completely within the network, need not be. Hardware is produced exclusively by large firms outside the network industry and software by firms both inside and out; lease and licensing mechanisms are available to spread out costs for the two items and to reduce entry and exit barriers. At the same time, while packet technology will push the most significant variable cost of remote data services--communications--well below present levels, there is every reason to expect that, particularly in view of the low fixed costs, the fixed to variable cost ratio can be expected to be far below the level at which natural monopoly characteristics begin to surface.

Innovation

While the argument that monopolistic firms are characteristically disinclined to innovate in their operations and in their

---

of competing transmission services, including Bell and Western Union services, from which the user of transmission facilities will be able to select the one best priced and situated to meet his individual needs.

What is critical about ARPANET's place in this picture is that it will be an entity consisting of users of transmission facilities--flexibly employing telephone, microwave and satellite links--and not a carrier--providing the necessary links. This suggests not only that the network market lacks the natural monopoly characteristics that traditionally call for common carrier treatment, but also that (1) existing common carriers would have good reason to encourage entry by a large number of network firms which, in competing for the sale of new communications services, can be expected to increase overall use of common carrier facilities and (2) to the extent that an existing carrier's objection to the entry of new firms is grounded in its own hopes of entering the network business, the argument reveals a carrier attempt to reach into untapped fields rather than a network attempt to enter the already tapped common carrier industry.

products and services has been persuasively answered,[33] this does not mean that regulated monopolies will behave similarly.[34] The regulatory practice of tying revenue to costs naturally produces some disincentive to innovate toward efficient operations. And while innovation directed toward the development of new products and services need not be similarly deterred, even here the requirement of regulatory agency approval may be a dissuasive force. There are some counters to this general disincentive effect. Thus, because regulated rates are almost always based on the firm's past performance, and are set periodically rather than continually, the firm has some reason to innovate and cut costs

---

[33] The argument that firms enjoying a monopoly position will be counter-innovative or, at least, will invest in the least efficient forms of innovation, rests on a number of assumptions--among them, that monopolists, because they are less cost-conscious than competitive firms, will be less concerned with cost-reducing and efficiency-promoting innovations; that the monopolist will either underinvest in research and development generally, or will over-invest to forestall entry when part of its monopoly market is competitively threatened; and that the monopolist will invest in research and development designed to buttress its monopoly position by extending scale economies and reinforcing other barriers to entry. See, for example, Shepherd, The Competitive Margin in Communications, in W. Capron ed., Technological Change in Regulated Industries 86 (1971). For a particularly effective rebuttal of the argument, see Posner, Natural Monopoly and Its Regulation, 21 Stan. L. Rev. 548, 577-584 (1969).

[34] Although it has been commonly supposed that regulation tends to inhibit innovation, "an apparent paradox is also recognized--if regulation has inhibited the pace of innovation, why have all the regulated industries enjoyed long-term productivity increases that are above the national average (and certainly higher than those in most manufacturing industries)?" Capron ed., Technological Change in Regulated Industries 3 (1971). In part, however, this general level of performance can be attributed not to regulation but to the surrounding natural monopoly conditions that called for its exercise--capital intensity, economies of scale--conditions that themselves would appear to enhance innovation. Id. at 221.

Regulation's counter-innovative effects in the communications industry have been carefully documented in Shepherd, The Competitive Margin in Communications, in id., at 86, which concludes that more, rather than less competition in the industry will best conduce to a desirable pace and direction of innovation.

in the interim, before new rates are set; thus, the presence of regulatory lag may exert some pressures toward economy in operations.

While innovation doubtless occurs in the rate base regulated firm, especially with respect to the creation and capture of new markets, this does not mean that the level of innovation will be optimal or, far more important, that the innovation produced will be of the proper kind. Thus, for example, because its revenues are tied to its level of investment, the regulated firm can be expected to seize every available opportunity to enlarge its rate base, a capital intensive bias that may lead it to prefer research and development directed toward capital intensive, but comparatively inefficient, production and service processes.[35] Misdirection of investment in innovation may also occur if it is general public relations, not specific consumer needs, that supply the motive for invention.[36]

This indicates only that the rate and direction of innovation are likely to be suboptimal in regulated industries whose firms are vertically integrated. Where there is some disintegration, and the firms supplying the regulated firms operate in a competitive environment, the degree of innovation with respect to the goods and services supplied that is present in other competitive

---

[35] The general bias, commonly called the "Averch-Johnson effect," is considered in Averch & Johnson, Behavior of the Firm Under Regulatory Constraint, 52 Am. Econ. Rev. 1052 (1962).

[36] Bell's expenditures on the Picturephone--tremendous when compared with its commitment to the development of digital transmission services, see Mathison & Walker, Regulatory and Economic Issues in Computer Communications, 60 Proceedings of the IEE 1254, 1255 (1972)--provides a good example of wrongly directed investment in innovation. The quality of Picturephone service is far from adequate, not because the research was done on the cheap, nor because the system lacks sophistication and considerable ingenuity, but rather because the extensive network of transmission facilities to which the Bell System is tied are just not set up for two-way video transmission. Much less research and development would have been needed to produce a system able to work better on some other transmission basis.

sectors may be expected to prevail.[37] The question, then, is whether, if certain components of the divested ARPANET are placed on a regulated, common carrier basis, other components, critical to innovation, can be isolated and left in a competitive setting. Unfortunately, because it is an entirely new system that is involved, and because it is in the nature of significant innovation that its outcomes and contours cannot be known at the outset, little can be accurately said about the proper locus of innovation until consumer needs become more defined and the outlines for responsive innovation become more clear. What can be said with somewhat more certainty is that, other things being equal, more in the way of appropriate innovation stands to be lost by placing any segment of the divested firm on a regulated footing rather than on one that is competitive.

REGULATION: THE AUTHORITY OF THE FCC

Arguably, Federal Communications Commission has the power to

---

[37] To some extent, this phenomenon was credited by the FCC in Use of the Carterfone Device in Message Toll Telephone Service, 13 FCC 2d 420 (1968). Issuing a sweeping condemnation of the carriers' foreign attachment tariffs (which prohibited use of hardware not obtained from carrier affiliates) to the extent that they were unnecessary to the maintenance of system integrity, the Commission immediately stimulated competition and innovation in the attachment hardware industry. See generally, Irwin, The Telecommunications Equipment Market--Public Policy and the 1970's, Fall Joint Computer Conference 269, 270-272 (1970).

Carterfone is at least indirectly relevant to the prospects for a divested ARPANET on two counts: first, in its broadest aspect, the decision reflects a policy that, when faced with new technological entities seeking connection with present carrier facilities, the Commission will place the burden on the carrier to establish that connection would materially impair the carrier's services and not on the proponent to establish that it would not. Second, by stimulating competition and innovation in the attachment hardware industry, Carterfone has dramatically increased the technological options available to network participants, in terms of both their freedom to fashion equipment to meet their special requirements and to purchase needed systems and devices in the market at competitive prices.

regulate the components of a divested ARPANET.[38] Title I of its enabling legislation, which empowers the Commission to "perform any and all acts, make such rules and regulations, and issue such orders, not inconsistent with this chapter, as may be necessary in the execution of its functions,"[39] may be interpreted to justify the regulation of institutions whose activities, not falling squarely within the scope of the Act, nonetheless impinge upon the Commission's regulation of activities that do--telephone common carriage and radio transmission. Perceiving a network threat to the integrity of the telephone system--by sloppy interconnection or diversionary pricing, for example--the Commission might find in Title I the required authority to regulate the network's activities generally. Similar reasoning formed the predicate for the Commission's early regulation of CATV functions[40] and, although there are important differences between the CATV context and the present one, it is significant that the rationale was expressly sustained by the Supreme Court in one of its infrequent reviews of an FCC decision.[41]

---

[38] The FCC's authority under Title II is, of course, confined to interstate and foreign carrier operations. It is entirely possible that the states, probably through their public utility commissions, and even some municipalities, will attempt regulation of intrastate network activities as they have done, to varying degrees, with CATV systems. <u>See generally</u>, Barnett, <u>State, Federal, and Local Regulation of Cable Television</u>, 47 Notre Dame Lawyer 685 (1972).

[39] 47 USC Sec. 154 (i).

[40] Second Report and Order in Dockets 14895, 15233, 15971, 2 FCC 2d 725 (1966).

[41] United States v. Southwestern Cable Co., 392 U.S. 157, 178 (1968):

> There is no need here to determine in detail the limits of the commission's authority to regulate CATV. It is enough to emphasize that the authority which we recognize today under Sec. 152 (a) is restricted to that reasonably ancillary to the effective performance of the Commission's various responsibilities for the regulation of television broadcasting.

Whatever the case for the existence of an incidental statutory power to regulate the divested network, it is by no means clear that the statutory language and the underlying legislative history command or even warrant an exercise of the specific power to characterize the network as a common carrier. The Act's definition of "common carrier" is singularly unhelpful--"'common carrier' means any person engaged as a common carrier for hire"[42]--and the legislative history is only slightly more enlightening: the statutory definition was said not to include "any person if not a common carrier in the ordinary sense of the term."[43] The "ordinary sense of the term," as it was understood by the Act's framers, may be generalized from three early instances of common carriage: ferryboats, railroads and the telephone system. Elements common to the three include a service, available to the public generally, for transporting persons, things or messages in unaltered form from one place to another. ARPANET would depart from these traditional contours in all important particulars: use of the system will, in the near term at least, be confined to commercial and government buyers; the very reason for use will be to obtain some significant alteration of the message conveyed, often with additional data returned; and though, to be sure, messages will travel from one site to another, the ticket will as likely as not be round trip, with processing, not switching, the significant function at the distant end.

---

[42] 47 USC Sec. 153 (h). The full definition reads:

> 'Common carrier' or 'carrier' means any person engaged as a common carrier for hire, in interstate or foreign communication by wire or radio or in interstate or foreign radio transmission of energy, except where reference is made to common carriers not subject to this chapter; but a person engaged in radio broadcasting shall not, insofar as such person is so engaged, be deemed a common carrier.

[43] Statement of Managers on the Part of the House, Conference Report on Communications Act of 1934, H.R. No. 1918, 73d Cong., 2d Sess., 45-46 (1934).

The Computer-Communications Inquiry

Although the FCC's own interpretations of its statutory mandate lend few more guidelines for answering the questions of whether and to what extent the divested network is to be regulated, its Computer-Communications Inquiry,[44] initiated in 1966, at least provides a starting point. The Inquiry, which culminated in a final order in 1971,[45] explored some of the knotty issues raised at the junctures between the telecommunications industry and the computer and data processing industries. Among other questions, the Inquiry considered whether services combining data processing--previously unregulated--and communications functions--pervasively regulated--should be regulated by the FCC. Avoiding the broader questions raised, the Commission decided only that regulation would be inappropriate for certain of the new forms of service, some of which--the so-called "hybird data processing services"--are markedly akin to the services that will be provided by the divested ARPANET.[46]

Defining "hybrid service" as an "offering of service which combines Remote Access data processing[47] and message-switching to form a single integrated service,"[48] the Commission drew the

[44] Notice of Inquiry, Docket 16979, 7 FCC 2d 11 (1966).

[45] In the Matter of Regulatory and Policy Problems Presented by the Interdependence of Computer and Communication Services and Facilities, Docket No. 16979, Final Décision and Order, 28 FCC 2d 267 (1971)

[46] "...[I]n view of all the foregoing evidence of an effective competitive situation, we see no need to assert regulatory authority over data processing activities whether or not such services employ communications facilities in order to link the terminals of subscribers to centralized computers." 28 FCC 2d 291, 298 (1970)

[47] "'Remote Access Data Processing Service' is an offering of data processing wherein communications facilities, linking a central computer to remote customer terminals, provide a vehicle for the transmission of data between such computer and customer terminals." 47 C.F.R. Sec. 64.702 (4) (1971).

[48] 47 C.F.R. Sec. 64.702 (5) (1971).

regulatory line between "Hybrid Data Processing Services" and "Hybrid Communication Services." The hybrid communication service, defined as a "hybrid service offering wherein the data processing capability is incidental to the message-switching function or purpose,"[49] would under the Order be subjected to regulation. The hybrid data processing service, described as "a hybrid service offering wherein the message-switching capability is incidental to the data processing function or purpose,"[50] would, for the present, remain unregulated.

Expressly rejecting the argument raised in several quarters, that it was "obligated by statute to regulate the 'hybrid service' as defined, insofar as such service contains a communication component,"[51] the Commission appears to have confirmed some rules of thumb it had earlier formulated for distinguishing between the two types of hybrid service:

> If...the package offering is oriented essentially to satisfy the communications or message-switching requirements of the subscriber, and the data processing feature or function is an integral part of and incidental to message-switching, the entire service will be treated as a communications service for hire, whether offered by a common carrier or non-common carrier and will be subject to regulation under the Communications Act. One applicable test will be whether the service, by virtue of its message-switching capability, has the attributes of the point-to-point services offered by conventional communications common carriers and is, basically, a substitute therefore. Another test will be the extent to which the message-switching feature of the service facilitates or is related to the data processing component, or whether such message-switching is essentially independent of such data processing.[52]

How the ARPANET would be characterized under these tests is far from clear. Two commentators have concluded, though without

---

[49] 47 C.F.R. Sec. 64.702 (5) (ii) (1971).

[50] 47 C.F.R. Sec. 64.702 (5) (i) (1971).

[51] Final Order in Docket No. 16979, 28 FCC 2d 267, 277 (1971).

[52] Tentative Decision in Docket No. 16979, 28 FCC 2d 291, 305 (1971).

much further explanation, that the ARPANET, "if offered on a commercial basis to the public at large would, under the Commission's present rules, have to operate as a common carrier."[53] The issue is, however, more slippery than this assertion might indicate for though, to be sure, point-to-point service is the essence of the network, the service is hardly a substitute for those offered by conventional common carriers and, as an economic matter, the message-switching feature is at best secondary to the data processing aspect with which it is closely related.

ARPANET: The Overlooked Threshold Questions

The real conceptual difficulty stems from the fact that ARPANET is generically distinct from the types of systems the Commission envisioned in the Inquiry. Where the Final Order contemplates a longitudinal division in a system's services, entailing, say, first transmission, then message-switching, then processing, ARPANET contemplates a division along latitudinal lines. Point-to-point communication is the crux of the system but, from start to finish, the messages transmitted will be processed, through methods including disassembly, reassembly and changes within the bit packets and sometimes through encryption. That data processing of a more complex magnitude will be performed at various points in the system in no way renders the packeting process any the less data processing. Thus, it is conceptually more accurate to characterize the network as itself a unitary, fully integrated computer, with communication facilities employed internally to link one function to another.[54]

---

[53] Mathison & Walker, Regulatory and Economic Issues in Computer Communications, 60 Proceedings of the IEEE 1254, 1259 (1972).

[54] Characterization of network operations as hybrid data processing services rather than as hybrid communications services may possess for network firms specific and important economic consequences distinct from those flowing from the Commission's general regulatory activities. Under the "authorized user" provisions of their tariffs, existing common carriers are constrained not to lease circuits to customers whose use would involve third party

These important technical differences aside, there are important policy reasons for withholding regulation from the divested network. Focusing on the question whether a new service's relationship to existing common carriers warrants regulation of the service, the Commission has overlooked a larger, threshold issue: whether the new service possesses those natural monopoly contours that historically have justified imposition of common carrier status.[55]

---

communications, essentially replicating the type of service provided by the carriers themselves. The effects upon network firms of a carrier denial under its authorized user provisions are different and certainly more immediate than Commission characterization and regulation of the firm as a common carrier: entry is chilled from the outset at existing carriers' private initiative.

The history of the Bunker-Ramo Corporation's efforts to lease Bell and Western Union lines for its Telequote IV service is instructive and is recounted in Irwin, The Computer Utility: Competition or Regulation? 76 Yale L. J. 1299, 1306-1308 (1967); D. Smith, The Interdependence of Computer and Communications Services and Facilities: A Question of Federal Regulation, 117 U. Pa. L. Rev. 829, 848-849 (1969), and, more recently, in Comment, Federal Communications Commission Regulation of Domestic Computer Communications: A Competitive Reformation, 22 Buffalo L. Rev. 947, 961 (1973).

[55] It is at best risky to speculate on the role that nomenclature plays in regulatory decisions, but it is entirely possible that the chance, academic characterization of early networks cognate to ARPANET as "computer utilities" played some part in the Commission's decision to view them as indicating regulation as public utilities. The term has, for better or worse, fallen into common parlance. See, e.g., D. Parkhill, The Challenge of the Computer Utility (1966); Irwin, The Computer Utility: Competition or Regulation?, 76 Yale L. J. 1299 (1967).

Paul Baran's early observation that "in essence...computer 'utilities' are not utilities" deserves more attention than apparently it has been given:

> The computer 'utility' user is not restricted to doing business with any one company. If you are not satisfied with your service, or are concerned about price, you can always 'go' elsewhere. Similarly, any single computer installation is not forced to serve all potential customers on an equal basis. The big customer may expect preferential treatment, either in terms of price charged or speed of service.

P. Baran, The Coming Computer Utility--Laissez-Faire Licensing or Regulation? (1967)

It is this overarching question--whether the market to be occupied by ARPANET will itself possess natural monopoly contours--and not the subordinate one--whether existing common carrier service will somehow be prejudiced by the network's operation--that properly forms the starting point for inquiry. Having the tail wag the dog is not an unpardonable act in all circumstances, but when it results in foreclosed consideration of central economic questions, it deserves to be discouraged.

V. REGULATION BY THE MARKET

The preceding discussion suggests that interests in the efficient supply of a wide range of computer communications services will probably best be served by an ARPANET situated in a vigorously competitive environment free from significant government control either through regulation as a common carrier or through ownership as a public firm. This means, first, that government should at some early point shed the bulk of ARPANET's components into the private domain, retaining, if any, only those few components--the basal R & D function is one--perceived as critical to the network's continued functioning in the public interest. It means, too, that divestiture should be to several firms rather than to one. To be sure, even if a network firm were structured along monopoly lines, there would be some element of competition in the sense that bidding for the monopoly franchise would be competitive and--if the franchise were durationally limited--continual. From the available evidence, though, it seems unlikely that competition in this form would stimulate a high enough level of continued and properly focused investment in innovation, and a sufficient degree of diversity and economy in services, to justify taking this route over the more thoroughly competitive one.

Third, barriers to entry should probably be kept low and, more important, kept uniform: ARPA must be vigilant to assure that all prospective entrants are given equal access to existing technical knowhow, whether developed within ARPA or by its contractors. Equality of access should effectively deprive any single firm of the sort of technological headstart that would likely lead to a monopoly position under present conditions and

should help to generate the needed degree of competition and diversity, both nationally and regionally. Assuring entry by firms of the appropriate size and number--the one justification for giving a firm or small number of firms the competitive advantage special access would entail--appears, from the facts available, to be attainable without this artificial inducement.

Although competitive conditions can be expected generally to discipline a network's firm's operational decisions--decisions respecting price, quality, marketing, material, labor and investment--toward achieving the larger objectives established for the network, the degree of success achieved by market forces cannot be expected to be uniform for all decisions. There may be some concern, for example, that the competitive firm's decisions affecting the quality of its services will not always comport with larger needs.

Specifically, there are two ways in which decisions on quality may be perceived to depart from desired norms. First, it may be feared that competitors will shave the quality of their services to a point beneath the standard of reliability essential to the network's integrity. The concern in this respect is that, absent regulation, breakdowns in quality might with distressing frequency go undetected until after their harm is done. When the harm is to highly sensitive interests, and threatens to be on a massive and unsettling scale, the need for prospective quality maintenance by an institution other than the private firm may be found compelling. It is perceived needs of this sort that sustain the federal Food and Drug Administration and that may be seen as calling similarly for government supervision of network performance quality.

Second, because any element in the network should be able to interconnect with any other element in the network, there is a need for compatibility and, consequently, for standardization of interconnection formats, the obvious comparison being to the early need for uniform gauge railroad track throughout the nation if rail transport was to enjoy a proper degree of efficiency.

Indecision and wrangling among network members as to the appropriate interconnection standard to be employed could lead to serious dysfunctions at the network's outset. In a related area, home-use electronic video recording, conflict over standards has plagued the nascent industry for years and may be the single most prominent reason for its failure so far to achieve viability. Even though there will be certain natural economies to standardization in the case of the ARPANET, so that the various systems can be expected to shake down over time to a single standard, the critical questions are how much time this will take and whether the losses to be sustained in the interim are sufficiently outweighed by the generalized advantages of strict reliance on the market.

Standardization and the maintenance of prescribed levels of service could be achieved under the techniques of retention or regulation discussed in earlier sections of this paper. Government could, for example, retain responsibility for developing interface and service standards, and could establish an agency to enforce the rules adopted. At least two other techniques, rooted in market rather than regulatory functions, are available for quality control within the evolved ARPANET. Under the first technique, government control would be accomplished through government purchase of services from the network, with the appropriate performance standards, presumably initiated by the government but tempered by negotiation, written into the service contract; this technique may be called "regulation by purchase." Under the second technique, which may be called "regulation by cooperation," quality control would be administered by a cooperative board or trade association consisting of members elected by network participants.

REGULATION BY PURCHASE

The federal government will be a major--and in the near term, the predominant--purchaser of network services. Indeed, it may

be said with some accuracy that the single most valuable asset to be received by successful ARPANET bidders is an implicit government agreement to purchase their services. As a purchaser, government may be expected to exert some special influence on network operation. Contracts might, for example, call for a government priority on the network's facilities and, in case of vital public need, for preemption of network time. Special government needs may also require the creation of bypasses in heavily traveled areas to assure the unimpeded flow of government and other user messages when peak periods coincide with emergency conditions.

It is the more general formative effects of government purchase that are of interest here. The government, particularly if it acts through a single broker rather than through a number of independent departments, will be in a unique position to affect the way in which network decisions on quality are made. Just as government could, through retention or regulation, prescribe interface standards and levels of performance in terms of errors permitted, reliability and data rate, so it could, by specifying its criteria as to any or all of these in its purchase contracts, stimulate network participants to meet these standards voluntarily.

The extent to which performance requirements in government contracts will have a spillover effect, establishing network performance at the same level for all users, private and public, will depend upon economies of network operation not yet fully discernible. If the hardware and software built to government quality specifications might efficiently be deployed to meet the needs of private consumers as well, and if economies of scale counsel against the construction of redundant facilities for the commercial sector, then the spillover will be complete and the regulatory consequences most effective. The economies involved in standardization suggest that government initiative in this respect will prove decisive.[56] Whether government leadership on other quality

---

[56] Decisive because so long as no network operator has an investment in, and consequently commitment to, any interface standard, each will be better off in adopting a standard that it knows will be adopted by all or most.

issues will be equally influential is open to question. Examination and comparison of the effects on private suppliers' decisions of compliance with government purchase requirements, as for example, Department of Defense purchasing specifications for pharmaceutical and medical supplies, may prove instructive in this respect.

The advantages of regulation by purchase, when it possesses extensive, if not complete, spillover effects, stem largely from its flexibility and specificity. To begin with, a market situation suffering the inflexibilities of the regulatory process would obtain only if government were a monopsonist, a position which, in connection with its purchase of network services, it would not occupy. Also, while some of the elements of a Turkish bazaar do creep into administrative hearings on proposed common carrier tariffs, and while, if regulated, network managers might be expected to have some say, informally and through the hearing process, in the promulgation of rules governing their firm's activities, the relevent interests would, on balance, probably be advanced and accommodated more effectively around the bargaining table, at opposite sides of a proposed contract. Also, regulation's "tar baby effect," already alluded to,[57] under which regulation of one aspect of an industry may quickly lead to the need for regulation of another, and still another, until a situation approaching complete government ownership results, can be avoided through the inclusion in purchase contracts of those specific parameters on which performance is desired.

REGULATION BY COOPERATION

General responsibility for prescribing and supervising the protocols and quality of network service might alternatively be vested in a cooperative organization or trade association consisting of network participants, with executive responsibility delegated to a governing board in which representation would be based on, among other factors, regional situation and user orientation. Membership in the association would presumably be open to all

---

[57] See supra, p. A-8.

network operators; the form of governance would be democratic.

The problem with the cooperative approach lies in the phenomenon observed by Adam Smith two hundred years ago, that "people of the same trade seldom meet together, even for merriment and diversion, but the conversation ends in a conspiracy against the public or in some contrivance to raise prices."[58] If trade associations are themselves generally unassailable on antitrust grounds, their decisions nonetheless invite government scrutiny for anticompetitive effects. And, while the courts, the Justice Department and the Federal Trade Commission have all shown some tolerance for cooperative endeavors respecting research, exchange of technical information, advertising standards and safety programs,[59] even some of these decisions may be proscribed if untoward effects on price and quality competition are demonstrated.

Thus, for example, cooperative programs to standardize products and services, while frequently sustained, necessarily produce some anticompetitive effects: the firm serving consumers who desire substandard services may be prejudiced and the standard itself may, by restricting supply, tend to rigidify price structures. Also, though one commentator has counselled that attempts to promote standardization should, for this reason, "probably be limited to such noncontroversial matters as the safety, and possibly the durability and efficiency, of the product,"[60] even safety programs can be faulted on policy grounds: the consumer who prefers a lower price to more safety may find

---

[58] A. Smith, Wealth of Nations, Book I, ch. 10 pt. II (1776).

[59] See Monroe, Practical Antitrust Considerations for Trade Associations, 1969 Utah L. Rev. 622-623 (1969). See generally, Borowitz, Joint Business Actions by Competitors: Are Any Permissible?, 32 Ohio State L. J. 683, 689-698 (1971); Levin, The Limits of Self-Regulation, 67 Colum. L. Rev. 603, 633-635 (1967).

[60] Monroe, Practical Antitrust Considerations for Trade Associations, 1969 Utah L. Rev. 622, 625 (1969).

his range of choice constricted.[61]

While questions of antitrust liability pervade the cooperative technique, a question larger than restraint of trade stands at the threshold: whether decisions which on their face seem best placed under cooperative control should in fact be centralized. One question, whether a cooperative mechanism should be employed to allocate among HOSTs, differentially, rewards corresponding to the utility of their programs, may prove particularly nettlesome. Absent some system of property rights, the HOST who invests heavily in the development of a new and useful program will, the program's high utility notwithstanding, be unable to recoup his investment: a competitor who has not similarly invested will simply cadge the innovator's technique and market it at a price equivalent to his marginal cost--a price that, given the low costs of replicating information, can be expected to be well below the innovator's average cost. Unable to recapture his investment through the price mechanism, the prospective innovator will be disinclined to innovate altogether, and one of the network's objectives, a high degree of program innovation, would be defeated.[62]

One remedy for this might be for a cooperative to tax all transactions and allocate the revenues among HOSTs in sums proportional to their contribution to the system. Cumbersome at best, a reward system of this sort would be largely unnecessary

---

[61] See Turner, Consumer Protection by Private Joint Action, 1967 N.Y. State Bar Ass'n Antitrust L. Symposium 36, 40. This position assumes, of course, that social welfare will best be served by the availability of the widest possible variety of goods and services, and necessarily ignores the persuasive argument that, as a function of overinvestment, some variety increases may be undesirable from the welfare standpoint. Cf. Markovits, Fixed Input (Investment) Competition and the Variability of Fixed Inputs (Investment): Their Nature, Determinants and Significance, 24 Stan. L. Rev. 507 (1972).

[62] See generally, Arrow, Economic Welfare and the Allocation of Resources for Invention, in Nat'l Bureau of Economic Research, The Rate and Direction of Inventive Activity: Economic and Social Factors 609 (1962).

if present systems of monopoly subsidy--patent, copyright and trade secret are the applicable candidates--could be counted on to give to programs the kind and level of protection that would enable recovery of research and development costs.[63] Yet, as presently framed, these three bodies of law offer sparse incentive for investment in software innovation: the Supreme Court has recently rendered a decision casting considerable doubt over the patentability of computer programs[64] and, though programs are presently accepted for registration by the Copyright Office,[65] the level of protection accorded seems hardly worth the registration fee.

Protection of programs as trade secrets, a technique widely employed in the software industry today, may be the answer for the future network as well, particularly if the network's high degree of security can be relied on to guard against the unauthorized disclosure of proprietary data. Yet, there, too, the Supreme Court has raised troublesome questions, intimating that the trade secret monopoly may improperly conflict with federal competitive principles and, for that reason, be invalid.[66] And, perhaps more important, reliance on a trade secret system may, since secrecy is its essence, undesirably inhibit the exchange of technical information and the development of new techniques from the teachings of preexisting knowledge--one of the signal values of the patent system.

If trade secret protection endures, or if present systems of monopoly subsidy are augmented by a new system for the

---

[63] Even with an adequately functioning system of monopoly subsidy, some program of rewards for major achievements, or prizes for attaining desired performance criteria, might provide a needed, auxiliary spur to innovation.

[64] Gottschalk v. Benson, 409 U.S. 63 (1972)

[65] Copyright Office Circular 31 D (May 1964). See generally, Cary, Copyright Registration and Computer Programs, 11 Bull. Copyr. Soc. 362 (1964).

[66] Lear, Inc. v. Adkins, 395 U.S. 653, 674-675, 676-677 (1969).

protection of computer programs,[67] it would seem that reliance on the property mechanism created, because consistent with the proposed generally competitive structure of the network, may be superior to a centralized system of rewards.[68] The problem of transaction costs--measured in dollars and delay--usually associated with the marketing of patents and copyrights need not obtain in the ARPANET, for the system's technology is uniquely situated to administer the bargaining and billing functions with a speed and efficiency not available in other industries.[69]

---

[67] See, e.g., Galbi, Proposal for New Legislation to Protect Computer Programming, 17 Bull. Copyr. Soc. 280 (1970).

[68] Compare Baxter, Legal Restrictions on Exploitation of the Patent Monopoly: An Economic Analysis, 76 Yale L. J. 267, 273-274 (1966).

[69] See Goldstein, Information Systems and the Role of Law: Some Prospects, 25 Stan. L. Rev. 449, 454 n. 15 (1973).

CONCLUSION

The central premise is that, properly analyzed, the public firm represents the last logical step in the regulatory process and that the determination to divest a public firm commands the kind, and at least the level, of consideration given the determination to regulate private ones. As applied to the ARPANET, this premise leads to the specific conclusion that while the risks associated with the network's initial, experimental stages justified formation as a public firm, the goals established for a fully distributed, commercially operative evolved ARPANET seem most likely to be fulfilled through the network's divestiture to a number of independent firms situated in a vigorously competitive, relatively unregulated, environment.

This means not only that as a general matter the free market solution should be preferred to the regulatory one--that, for example, the divested network should be placed beyond the grasp of the FCC--but also that the market to which the network is divested should be insulated from avoidable anticompetitive clogs. Care must for this reason be taken in the disposition of present network assets--knowhow particularly--that unjustified competitive advantages not be afforded and entry barriers indiscriminately erected.

It should be underscored that the reason our economy generally relies on private markets rather than on courts, legislatures and regulatory agencies to shape firm decisions respecting price and quality is that the market seems the most fluent mediator between the profit motive and consumer demand. Because consumer choice is the economy's touchstone, the

question facing the economic planner is, in a very real sense, not whether decisional power should be lodged in government or in the firm but, rather, whether it should be lodged in government or the consumer. Because government is both a prospective regulator and prospective consumer of the services to be provided by the divested ARPANET, it will be doubly postured to influence firm decisions. Because, as applied to the ARPANET, the regulatory process will suffer formative deficiencies not shared by the purchasing process, it is the latter that recommends itself as a means for channelling network decisions in the desired directions, particularly since, unlike exercises of the regulatory power, exercises of government purchasing power will naturally diminish in effect precisely at the times when diminished effects will be most appropriate: as the network moves in the longer term toward a larger, more varied and commercially oriented customer base.

APPENDICES ON INSTITUTIONAL ISSUES-PREFACE

(Appendices B through F)

This section of the report consists of five separate appendices all relating to institutional alternatives. They are numbered as Appendices B through F. They were all prepared primarily by Marc U. Porat.

The first of these separate appendices, B, reviews alternative industrial structures possible; describes the present trajectory of development towards one of these possibilities as being most likely unless active reconsideration is taken; and it describes what the writer believes to be the most desirable course of action and the reasons for his position. In support of his arguments useful background information is presented reviewing some of the most recent changes taking place.

The second appendix in this series of five, Appendix C, is a detailed description of the operation of a possible consortium or industry association of packet switching entities including suppliers and users. This appendix provides much fine grain detail discussion of the day-to-day procedural operation of an imaginary consortium and provides a flavor of how such an organization might work. A fine level of detail is included in this report since the concept of a consortium has not been considered before in this application. It was felt that filling in some of these details would help improve the usefulness of discussion about possible organizational arrangements.

The third appendix in this series, Appendix D, is a Delphi exercise prepared early in this study. In this the staff considered a spectrum of alternative options; narrowed them down to four and then expressed their subjective judgements. Considered were differences in the characteristics, and expected operational behavior. This appendix here suggests the broad range of alternative institutional arrangements initially considered and some of the reasons why certain arrangements were narrowed for further investigation.

Appendix E is a simulation also performed early in the project. It examines the expected behavior patterns of competing organizations in the hypothetical situation where such organizations owned different segments of a single network, and where strict rules of behavior, specified in advance, were followed. This appendix addresses the question as to whether actions beneficial to the entire network would result if each separate owner made decisions solely in its own best interest. The appendix shows how one might go about programming this behavior, to predict performance in advance of a real world situation.

Lastly, in this set of appendices is Appendix F which is the users manual for the simulation model described.

Appendix B

INSTITUTIONAL ALTERNATIVES

by

MARC U. PORAT

B

PREFACE

The emergence of a packet switching network industry introduces unanswered questions and potential benefits to the producers, the consumers and the government. This appendix considers one viewpoint of the present trajectory embarked upon by the new industry and suggests reasons for an alternative consideration by the major interested parties.

These arguments are tentatively planned to be explored in further detail and a Working Paper may issue in 1974.

SUMMARY

Since packet switching is an immature industry, the example of the specialized common carriers (SCC) and the value added networks (VAN) will be used as a parallel for discussion. The birth of these common carrier-like services was accompanied by aggressive legal and economic maneuvering and counter-action on the part of both the existing regulated utilities and the would-be entrants. The past issues and the specific positions taken by the various actors will be discussed because of their present implications. Factors to be considered are the regulatory boundary, interconnection, third-party resale, tariff offerings, VAN's and Section 214, and credibility. Using this background as a basis for prediction, the writer concludes that the packet switching business shows a clear tendency towards an eventual oligopolistic industry structure.

An oligopoly here operating under regulated competition appears to contain several generally undesirable economic fall-outs: a tendency toward resource sharing inefficiencies, price discrimination, and imperfect market performance. These could result in depressed joint industry profits, suppressed industry growth, higher prices to the consumers than might otherwise be necessary, and continued regulatory disputes. Such sub-optimal outcomes are said to result from the nature of the structure of the industry, which prevents the separate entities from cooperating among one another to joint and mutual benefit.

This appendix considers the alternative of a more cooperative structure. While there are a variety of alternative arrangements possible, ranging from laissez faire industry to

full horizontal monopoly, the realistic spectrum is much more limited. There is no recent history of laissez faire working in similar cases for the regulated common carriers while horizontal monopoly begs regulation. The narrowed spectrum of allowable arrangements is further restricted when antitrust issues are considered.

What appears to be needed is a cooperative industry arrangement in which government is a member. This arrangement could be cooperative, such as a farm cooperative, or as an industry clearinghouse, such as ASCAP or as a consortium such as EDUCOM. The exact structure is secondary to purpose. For the purposes of discussion it is called the Packet Switching Consortium, or "consortium," for short.

The three critical functions of this consortium or consortium-like organization are: 1) to facilitate entry; 2) to establish universal interconnection between member networks; and 3) to serve as a payment clearinghouse to administer shared costs. The economics of this consortium suggest, as will be shown, that a sizable measure of resource sharing and economies of scale is possible. By guaranteeing free entry into the consortium and requiring universal interconnection, entry and operating costs will be substantially reduced, and some antitrust problems will be avoided as well. Such an arrangement could also accelerate the propagation of the new services into the least profitable markets, and could increase the variety of offerings brought to the marketplace. The existence of a consortium-like arrangement could create conditions to aid innovation and R&D investments by offering its members a higher degree of market security and a competitive environment in the areas where competition aids the consumer. By sharing facilities, it is suggested that the market could operate at a higher degree of efficiency to the benefit of both the consumer and the producer. Lastly, it is held that the FCC could be relieved of many regulatory functions, since the consortium is, to a major degree, self-policing. It is always vulnerable to antitrust action should it exceed its legal perogatives.

TYPOLOGY OF INDUSTRY STRUCTURES

In Figure B-1 the spectrum of possible structures of the data communications networks industry is organized into a 2 x 3 matrix.

The rows separate the structures into regulated versus non-regulated domains. Of course, the dividing lines are merely illustrative. But, for purposes of discussion they allow a useful differentiation.

The columns divide the entire market characteristic spectrum into three distinct groupings. These are labeled monopoly, oligopolistic competition and pure competition. A purist would argue that there is no such thing as a perfect monopoly as there is no pure competition. These are merely useful categories which permit us to discuss the almost infinite range of possible alternative arrangements and describe them as locations in a simplified matrix. In the matrix, the boxes are labeled Type 1 through Type 6 to facilitate discussion.

Now let us consider which of these boxes represent more reasonable and realistic alternatives. Later we shall consider the question of desirability in more detail.

TYPE	MONOPOLY	OLIGOPOLISTIC COMPETITION	PURE COMPETITION
REGULATED	AT&T common carriers (1)	The present trajectory MCI, DATRAN, PCI, TELENET, et al. (2)	Non-existent by definition (3)
UNREGULATED	Non-existent by definition (4)	Television networks (5)	Nearest workable approximation = consortium (6)

Figure B-1. Typology of Structures for Computer Communication Industry.

These six possible outcomes of Figure B-1 can be narrowed down to two most realisitc outcomes by the following rationale:

In the Type 1 case, the regulated monopoly, the FCC has determined that as specialized common carriers are legitimate enterprises in the public interest, it must follow that economies of scale are not sufficient to preclude entry into the field. Entry costs for specialized carriers ranging from $50 million to $250 million have been experienced, well below the barrier to entry which seems to define a "natural monopoly." And, the entry price for packet switched carriers is even less -- in the $20 million range. Each entrant to the new industry has a fair degree of price control, suggesting that a unique monopoly price does not exist and that monopoly power can be challenged successfully. Not convinced by the FCC viewpoint in this matter, AT&T has recently argued that the whole specialized carrier industry should revert to a regulated monopoly, or at least that there should be a moratorium on new approvals.

Type 2, the natural regulated oligopoly, appears to be a more likely present trajectory. It will be argued below that this trajectory will lead to sub-optimal industry growth.

Type 3, the regulated pure competition, is non-existent by definition, as is Type 4, the unregulated pure monopolist.

Type 5, the unregulated oligopoly, is a viable alternative but has, for historical reasons, been supplanted by Type 2. The difficulty is achieving it as a stable state of nature. The long-run equilibrium of a perfectly competitive industry is characterized by:

1. Price equals marginal cost. In a perfectly competitive economy, a firm's output decisions do not affect industry prices (the absence of monopoly power). Hence, profits are maximized when price is set equal to marginal cost.
2. Supra-normal profits are avoided and consumer surplus is maximized.

3. Each firm produces output at the low point of its average cost curve; firms which over- or under-produce are eventually eliminated from the market. Thus, efficient resource allocation is assured.

However, the underlying communications media employed by the new packet switching industry (cable, microwave, satellite) have been traditionally subject to regulation. The introduction of the computer as a communication switch has confounded the analysis sufficiently that it, too, is almost by default being included under the regulatory umbrella. The point will be developed later that an oligopolistic industry, whether regulated or not, is a less desirable alternative. Thus, the exclusion by default of Type 5 is not a source of major concern.

Type 6, the unregulated pure competition, is generally held by most economists in the U.S. as being theoretically the most desirable of outcomes and the case for competition has been advanced in numerous economic tracts.*

In summary, the feasible outcomes of industry structures are represented by Type 2 and Type 6. The present trajectory appears to suggest a Type 2 industry, while the author believes that the normative position of a Type 6 structure is more desirable, if achievable.

However, the Type 6 outcome is unattainable in its pure form owing to factors that will be discussed in detail below. A second-best approximation is proposed in the form of a self-regulating and competitive consortium-like arrangement of computer networks.

----

* See, F. M. Scherer, Industrial Market Structure and Economic Performance, Chicago: Rand-McNally & Co., 1970. Chap. 2

RELEVANT BACKGROUND

Let us now consider the debates now going on in the regulatory agencies and the courts as new specialized carriers are born as they may apply to packet switching. Packet switching faces a somewhat different set of problems than do the specialized carriers, but whatever happens to the specialized carriers is, to a degree, relevant to packet switching, whether it be in rates charged for trunks or degree of freedom of action.

The MCI and DATRAN Specialized Carrier Applications

In 1968, Microwave Communications Inc. (MCI) filed an application with the FCC to operate a microwave link between St. Louis and Chicago. MCI proposed to offer data services to customers at a considerably lower price than was then available through AT&T. MCI planned to use local telephone lines to distribute, connecting with telephone company facilities on MCI customers' premises, and using its own microwave relays for inter-city traffic. AT&T responded vigorously, alleging that MCI was proposing to re-sell communication service to a thrid party, and that such practice violated AT&T's tariff. The AT&T response sparked an intense legal battle.

MCI won its first round with AT&T when the FCC granted the company's application in FCC Docket #18920 as a Section 214 Specialized Common Carrier. The FCC further ordered AT&T not to delay service to MCI and to immediately effect interconnection of telephone company equipment with the specialized carrier's equipment. Shortly following the MCI grant, the FCC approved a similar application for the Data Transmission Corporation (DATRAN).

Existing Carrier Response

AT&T has responded to MCI and DATRAN in two closely linked countermoves: (a) by seeking to delay interconnection and (b) by offering a competing service. These developments are examined to provide a flavor of the difficulties encountered in regulated oligopolistic competition.

A major change in a long term prohibition against interconnection occurred with the historic Carterfone case, wherein telephone companies were compelled by law to provide interconnecting service to non-telephone-company-provided facilities. The argument raised by the telephone company then, as now, was that serious degradation of service would result (with eventually increased costs passed on to the subscriber) by attachment of equipment potentially harmful to the telephone system. MCI claims that it has been experiencing difficulties inducing AT&T to offer local interconnection with MCI trunks, despite the Carterfone ruling and despite the FCC order granting MCI's application under Section 214 specifying that AT&T was not to delay service to MCI and to effect interconnection.

As an accommodation to Bell's fears regarding system degradation by foreign equipments connected to telephone lines, the FCC requested that data access arrangements (DAA) and a certification program be established between Bell and potential entrants.

This middle ground position is proving to be unpalatable to AT&T, as its Chairman, Mr. John de Butts, in a recent speech before the National Association of Regulated Utility Companies (NARUC), stated that "we cannot live with the deterioration of network

performance that would be the inevitable consequence of 'certification' and the proliferation of customer-provided terminals that would ensue from it."* Chairman de Butts also called for a "moratorium on further experiments in economics" aimed at increasing competition in the telecommunications industry. In a departure from past AT&T policy, de Butts called for *more* regulation from the FCC, to halt the growth of regulated competition and to restore AT&T its natural monopoly. In a thirty-nine page petition to the FCC on October 4, 1973, Bell asked the Commission "to defer from granting further applications for facilities by the new competing carrier entrants pending outcome of ... evidentiary hearings."** Calling "dismal" the record of regulated competition, AT&T cited the railroad industry as a prime example. AT&T's position here appears to be to delay interconnection while trying to show the FCC the folly of its recent liberalization of entry rules and encourage it to return the telecommunication industry to a fully regulated monopoly (Type 1).

It is late in the game for changes as present estimates for the specialized common carrier industry suggest that it will grow from $1.45 billion in 1972 to an estimated $7.6 billion by 1980.*** This is too great a vested interest constituency to go away quietly.

AT&T has shifted the battleground away from the national level and into the state level. The reason, in part, is that the losers in the game of non-averaging will be the rural areas who would lose their invisible subsidy. Citing Section 2(b) of the Communication Act of 1934 (....), AT&T argues that Congress clearly intended to leave intra-state communication regulation to the states.**** The focal point of state action on interconnection problems is presently in states' rights conscious North Carolina, which had as recently

----

* Telecommunications Reports, #38, 9/24/73.

** Telecommunications Reports, #40, 10/9/73.

*** Market study by Frost & Sullivan, "The Specialized Communication Market" in Telecommunications Reports, #36, 9/10/73.

**** Telecommunications Reports, #44, 11/5/73

as mid-1973 threatened to flatly deny any and all interconnection. The arena is notably much larger, with skirmishes also being fought in Alabama, Arizona, California, Colorado, Illinois, Iowa, Maryland, Mississippi, New Jersey, Oregon, Pennsylvania, Nebraska, Tennessee, Texas, Virginia and Wisconsin. Early decisions in North Carolina and Nebraska are temporarily stalled with commissions gathering evidence to legitimize a ban on interconnection. MCI has filed an injunction in Philadelphia to force AT&T to interconnect, and has also initiated a letter-writing campaign to its customers (including one hundred firms in Fortune's 500) urging the FCC to take a more active role in the proceedings. (MCI's Chairman McGowan stated that "if we're unable to get interconnection, we'll go out of business tomorrow.")*

Financial Impact

The adverse financial impact is being felt throughout the specialized carrier industry. DATRAN stated that its line of credit has dried up domestically and they have sought (and received) capital from abroad. Even USTS, the ITT subsidiary, which has access to its major capital generating parent and which is faced with a relatively low cost of entry of about $25 million, is claiming hardship. In a recent statement,** USTS claimed that "financing problems of the specialized common carriers were brought about, in part, by the generally unfavorable attitude of the financial markets toward new ventures. This unfavorable attitude was further complicated and prolonged by the continuous rumors of the future competitive actions of established carriers. Announcements concerning present and future competitive rates, services and facilities by the established carriers have seriously stifled the financing plans of the emerging carriers and have seriously impaired their financial and therefore their competitive viability...."

----

* Telecommunications Reports, #46, 11/19/73.

** Telecommunications Reports, #28, 7/16/73.

Antitrust Suits

Another, somewhat related development has been a series of antitrust suits around the country by equipment manufacturers seeking totally unfettered interconnection to Bell. A recent case, seen by some as another Carterfone, is the MACOM Products Corporation vs Bell. MACOM produces the "Name Caller" automatic dialer, a small device that attaches to Bell lines and dials frequently used numbers automatically. Bell has refused interconnection, citing harm and system degradation. This suit is said to form a direct test of the applicability of the Sherman Act, and seeks to settle whether or not the Act prohibits telephone companies from restricting interconnection.* The court decided that the Communication Act does not immunize the defendant from antitrust regulation and has requested the FCC to aid the court in gathering "harm data."**

Independent Telephone Companies

The independent telephone companies generally have concurred with AT&T's position, but with some exceptions. On the one hand, Hugh P. Wilbourn, Jr., President of Allied Telephone Company, Little Rock, Arkansas, advises that, like Winston Churchill's wartime England, the telephone industry should fight "in every arena -- state commissions, courtrooms, and the FCC (to) defend the fully integrated network it has built over the past one hundred years ... against a small band of willful men in government and academic circles who are determined to foster competition in the regulated, franchised telephone industry.... The horror stories on service problems are beginning to come in from around the nation."***

On the other hand, Paul Henson of United Telecommunications Incorporated feels that interconnection is "here to stay," and "it

----

* Telecommunications Reports, #14, 4/9/73.

** Telecommunications Reports, #24, 6/18/73.

*** Telecommunications Reports, #37, 10/17/73.

is better to bend (with the wind) than break." He adds, "the world's greatest telecommunications system is threatened more by other forces than it ever will be by a limited amount of regulated competition."*

Congressional Review

The antitrust implications raised by AT&T's position are not lost in Congressional circles. In the summer of 1973 the Senate Committee's Antitrust and Monopoly Subcommittee under Chairman Philip Hart (D.,Mich.) chose to investigate communications as the first of seven industries, and held hearings from July 30 to August 2, 1973.

AT&T defended its anti-interconnection position by arguing that MCI is cream-skimming the density routes.and effectively stealing traffic from Bell, since MCI is not faced with cost-averaging over all markets -- including the not so profitable rural areas.

AT&T/DDS

AT&T has developed a new technology called Data Under Voice (DUV) which it is proposing to market under the ATT/DDS (Digital Data Services) offering. MCI and DATRAN oppose the new offering, seeking to convince the FCC that DDS is anti-competitive and will destroy the specialized common carrier industry. (ATT/DDS will in all likelihood seriously undercut MCI's and DATRAN's prices.) DATRAN has recently filed a motion that DDS development be subjected to a five-year moratorium, but the FCC denied the motion.** The DUV offering is expected to enjoy enormous price advantages by using underutilized bandwidth in AT&T's long-lines. By incurring a small capital expenditure when compared to the cost of building a network from scratch, the unused bandwidth can be used for data. Hence,

----

* Telecommunications Reports, #43, 10/29/73.

** Telecommunications Reports, #44, 11/5/73.

DUV can be charged at close to the marginal cost, rather than the average cost. It is to AT&T's advantage to demonstrate to the FCC that its capital outlays were small, since by the fair rate of return rule its tariff would be concommitantly small -- and undercutting of MCI and DATRAN rates could be achieved while playing the game according to the rule of "if there is going to be competition allowed, we can compete also."

The specialized common carriers understand this very well, and have charged that AT&T is being unfair in its cost allocation. "At the same time that it is raising monopoly telephone rates elsewhere, AT&T is making elaborate plans to cut its prices selectively in those relatively insignificant areas where it is beginning to face competition.... [This "hi-lo" plan] purports to be a departure from nationwide averaging, but it is actually only a two-tier scheme of averaging: low average rates will prevail where competition is threatened, and high average rates will be charged where AT&T has no competition."* The specialized carriers' arguments were to no avail, and following a favorable U.S. Court of Appeals ruling in New York, AT&T filed the "hi-lo" tarrif with the FCC, to be effective January 14, 1974.** In partial response to the anticipated "hi-lo" defeat, MCI filed its tariff as a three-tier national averaging scheme. The issue of pricing is by no means dead, since it is unlikely that the specialized carriers have reached a price equilibrium. Another view is that a classical price war is being fought, but is less noticeable than a "gas war," under the slightly astigm tized and distorted environment of regulated competition.

In partial response to price (tariff) maneuverings, the FCC now requires that any carrier who offers new classes or sub-classes of service shall give sixty days notice at the time of filing new or revised tariff schedules.***

----

* Telecommunications Reports, #20, 5/21/73.

** Telecommunications Reports, #46, 11/19/73.

*** Computer Decisions, July, 1973.

A case in point that bears major implications to the development of the commercial packet switching industry trajectory derives from Packet Communications, Inc. application before the FCC. PCI applied to the FCC under Section 214 of the Communication Act to gain quick entry into the industry.* PCI is a member of the vague class of "value added networks" (VAN's) which are, under under the value-added concept, permitted to re-sell communication services leased from AT&T to private users, provided that more than simple reselling takes place. As PCI is a packet switched system, it uses computers to route, perform error-checking and provide billing. Hence, it can be argued to fall within the yet not completely defined class of hybrid carriers. There is equally strong ground for PCI to force a rulemaking procedure by the FCC and take the position that VAN's are not really carriers and hence not subject to FCC regulation, since they are really unregulated competitive enterprises. In the writer's opinion, it would be to PCI's long-term advantage to be freed from the constrictions of the regulatory environment, but in the short run, it would have meant the start of an interminable set of proceedings before the FCC. Such a battle would be very costly, since PCI, a new small company, might face the combined opposition of AT&T, Western Union, MCI and DATRAN -- both the common carriers and the specialized carriers. PCI weighed the long-run costs of pursuing the 214 application against the short-run costs of being barred from entry altogether, and chose the former. Telenet, which also has an application outstanding, noted with pleasure the Commission's policy of liberalizing the authorization of other VAN applications.

The outcome of these battles at the fuzzy portion of the regulated/unregulated spectrum has broad implications for a potentially much larger matter of concern to ARPA-IPT's interests in aiding the development of computer resource sharing in this country. Computer resource sharing requires communications in combination with remote processing or access to remote data

----

* Telecommunications Reports, #4, 1/29/73.

bases. Yet, the carrier licensed to use data technology believes in a right unto perpetuity to provide such communications. Thus, Western Union consistently holds that the information utility services and resource sharing activities are merely telegraph-type services that they alone are franchised to provide. Among the shared data base systems that Western Union has regarded as violators of their historic charter include: Graphic Scanning Corporation (facsimile), Graphic Sciences Inc. (facsimile), Titan Industries (the Hilton Hotels subsidiary), NCS Computing, Comdata Network (offering the trucking industry a money transmission facsimile), Transceiver Corporation (interstate message, permit and money transactions), Transport Data Communication (message switching), and Xerofax Incorporated (interstate message, permit and money transmission).

It is difficult to estimate the number of new information services that have a substantial potential market and are being delayed because the would-be entrepreneurs are awaiting final judgment on the interconnection issue. In the interim, the social costs of delaying the implementation of these information services are borne by the public.

It is also difficult to present the full flavor of the debate going on at the FCC on the issue of packet switching. (Cabledata Associates has been compiling and organizaing this material and has sent copies to Range Measurements Laboratory with actions up to November 1973.)

However, one new major decision should be noted: that the FCC has approved the PCI Section 214 application. One may argue that the issue is now finally determined -- that this business will now and always fall under the regulatory jurisdiction of the FCC. But in this business nothing is fixed, it is just made more difficult. For example, in PCI's approval, the FCC said, "In the event that PCI in the future should seek to modify its basic service offering in a manner that will alter its status as common carrier ... PCI will be obliged to obtain prior authorization for such change...." Potentially, PCI could ask for de-classification

as a Section 214 Common Carrier and, possibly, total removal of regulatory power over the firm's operation, but it is now clearly within acknowledged FCC jurisdiction. It is still always possible for the whole industry to police itself in a manner that protects the public against the abuses that motivated the creation of regulatory law in the first place, but such reversal of the industry structure would require a remarkable degree of unity on the part of the new firms. And, if recent events are valid indicators of future actions, the firms are eminently prone to in-fighting and to seizing immediate short-run opportunities so that a cooperative industry action does not seem to be feasible in the short term without sufficient additional motivation.

Let us now consider the nature of the regulated oligopolistic structure further.

ANALYSIS OF DATA CARRIERS

The following section presents an economic analysis of an oligopolistic industry, the computer communications industry. Although it is a regulated industry the following remarks will be seen to be relatively insensitive to whether the industry is regulated or is unregulated. The analysis is considered from the firm's point of view, assuming initially no regulation. Superimposing regulation on the structure would merely possibly reduce viability and profitability for the whole industry and not affect the discussion. Again, in the following we disucss specialized carriers as well as packet switching carriers because of the greater measured experience. There are sufficient parallels to allow drawing of conclusions from the history of one sector to another.

As of November 1973, eleven companies are either in or have formally announced their intention of entering the computer communication business. This list includes existing carriers, specialized common carriers and packet switching carriers. All have issued tentative development plans, including technical specifications, costs and site installations. About five of the firms are operational, four more are expected to be fully operational by 1974, and two others plan to go into full service in 1975. In addition, a twelfth firm has announced that it is signing contracts for domestic satellite data transmission between seven metropolitan centers. All twelve firms are partially operational today, with some in the early shakedown stage. Figure B-2 shows an over-lay map of these twelve firms' announced topologies. Since each of the larger firms will have more than one route between the cities shown below, Table B-1 and Table B-2 show only city-to-city pairs, not number of trunk circuits available.

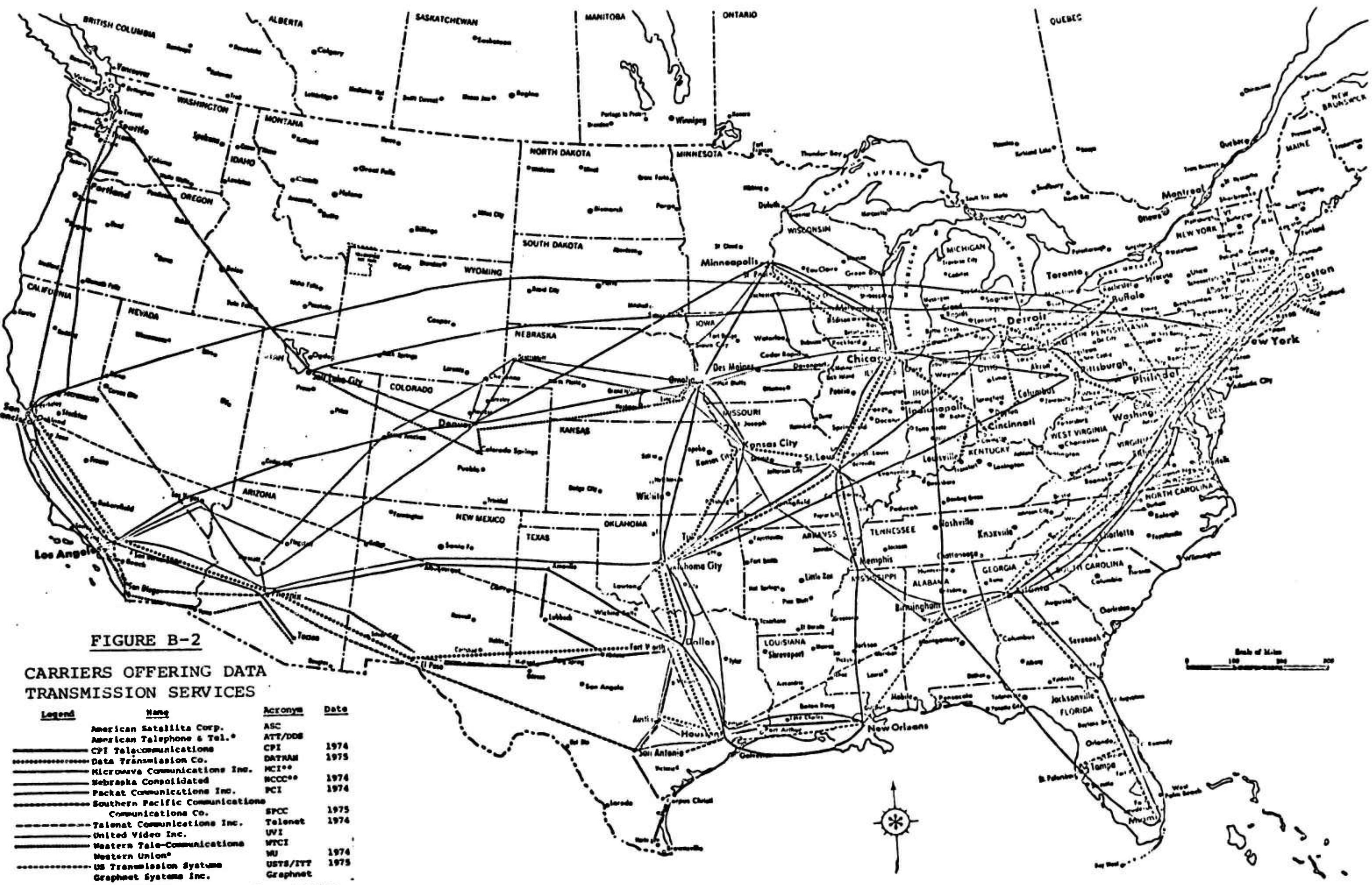


FIGURE B-2

CARRIERS OFFERING DATA TRANSMISSION SERVICES

Legend	Name	Acronym	Date
	American Satellite Corp.	ASC	
	American Telephone & Tel.*	ATT/DDS	
	CPI Telecommunications	CPI	1974
	Data Transmission Co.	DATRAN	1975
	Microwave Communications Inc.	MCI**	
	Nebraska Consolidated	NCCC**	1974
	Packet Communications Inc.	PCI	1974
	Southern Pacific Communications Communications Co.	SPCC	1975
	Telenet Communications Inc.	Telenet	1974
	United Video Inc.	UVI	
	Western Tele-Communications	WTCI	
	Western Union*	WU	1974
	US Transmission Systems	USTS/ITT	1975
	Graphnet Systems Inc.	Graphnet	

* Carriers not shown on map because precise locations are not yet known.

** MCI and NCCC have agreed to a merger in early 1974.

TABLE B-1

CITIES WITH SERVICE PROVIDED BY ALTERNATIVE CARRIERS

	ASC	ATT	CPI	DATRAN	MCI	NCCC	PCI	SPCC	UVI	WTCI	WU	T	
Seattle							●	●		●		●	4
Portland							●	●		●			3
Sacramento							●				●		2
San Francisco				●			●	●		●	●	●	6
Los Angeles				●	●	●	●	●		●	●	●	8
San Diego				●	●		●	●		●			[illegible]
Salt Lake City							●			●	●		3
Denver						●	●			●	●		4
Phoenix					●	●	●	●		●			5
Minneapolis				●		●	●					●	4
Milwaukee				●	●		●					●	4
Omaha						●	●			●	●		4
Chicago		●		●	●	●	●		●		●	●	8
Cincinatti				●							●		2
St. Louis				●	●	●	●	●					5
Kansas City						●	●		●				4
Tulsa				●									1
Oklahoma City				●	●	●			●				4
Fort Worth			●				●	●					3
Amarillo			●										1
Dallas			●	●	●	●		●	●		●	●	8
Austin			●								●		2
San Antonio			●			●	●	●					4
El Paso			●					●		●			3
Houston			●	●	●	●	●	●	●			●	8
New Orleans			●				●		●				3
Memphis						●	●	●					3
Birmingham						●							1
Miami									●				1
St. Petersburg									●				1
Jacksonville									●				1
Richmond						●	●		●				3
Washington, D.C.		●		●	●	●	●		●		●	●	8
Philadelphia		●			●		●					●	4
New York		●		●	●		●		●		●	●	7
Baltimore				●			●						2
Pittsburg				●	●							●	3
Hartford				●									1
Boston		●		●			●				●	●	5
Cleveland					●		●					●	3
South Bend					●								1
Detroit					●		●				●	●	4
Grand Rapids				●									1
Atlanta						●	●		●		●	●	5
Hobbs			●										1
Corpus Christi			●										1
Louisville				●									1
Indianapolis				●									1
Las Vegas						●							1
Buffalo							●						1
Rochester							●						1
Columbus							●						1
Augusta									●				1
													170

N=52

TABLE B-2

INDEPENDENT PAIRS

Point-to-Point		Number of Independent Pairs	Number of Redundancies
Seattle	Portland	2	1
San Francisco	Los Angeles	5	4
Los Angeles	San Diego	3	2
Los Angeles	Phoenix	2	1
Denver	Omaha	3	2
Minneapolis	Milwaukee	2	1
Milwaukee	Chicago	2	1
Chicago	St. Louis	2	1
St. Louis	Memphis	3	2
Kansas City	Oklahoma City	2	1
Oklahoma City	Dallas	5	4
Dallas	Houston	6	5
San Antonio	Houston	4	3
Houston	New Orleans	2	1
St. Petersburg	Miami	2	1
Atlanta	Richmond	2	1
Richmond	Washington	2	1
Washington	Philadelphia	6	5
Philadelphia	New York	7	6
New York	Boston	7	6
Pittsburg	Cleveland	2	1
Cleveland	Chicago	3	2
			52

These twelve firms, ranging from the giant AT&T to mid-size Southern Pacific and Western Union, to the tiny CPI Telecommunication all plan to serve a total of 52 cities in the continental United States. The matrix of cities by firms is presented in Table B-2. When Table B-2 is plotted on a graph, an interesting pattern emerges (see Figure B-3): a Zipfian distribution forms, conforming to

$$Y = \frac{20\ K}{X} + e$$

where Y = number of cities served
x = number of competitors in city
k = constant multiple
e = error term.

A short summary of the graph reveals that

Number of sites	131
Number of cities	52
Mean sites/city	2.6
Mode sites/city	1.0
Median sites/city	3.0
Standard deviation	2.15.

The present trajectory reveals a clear pattern of the emergence of a classical oligopolistic industry. The average number of companies serving a city being 2.6 and the dominant mode at a monopolistic one firm per city. Each firm presented its prospectus with some, if not full, regard for its competitors' intentions, and whereas the largest metropolitan areas are amply covered (by four, five, six and even seven firms), the smaller ones are essentially selected to minimize competition. A very primitive form of geographical differentiation appears to be occurring. The pressure from oligopoly to monopoly are increased by the presently weak venture capital market. The smaller firms all face very rocky shores in their attempt to establish a market beachhead, in part because the legal questions of regulation

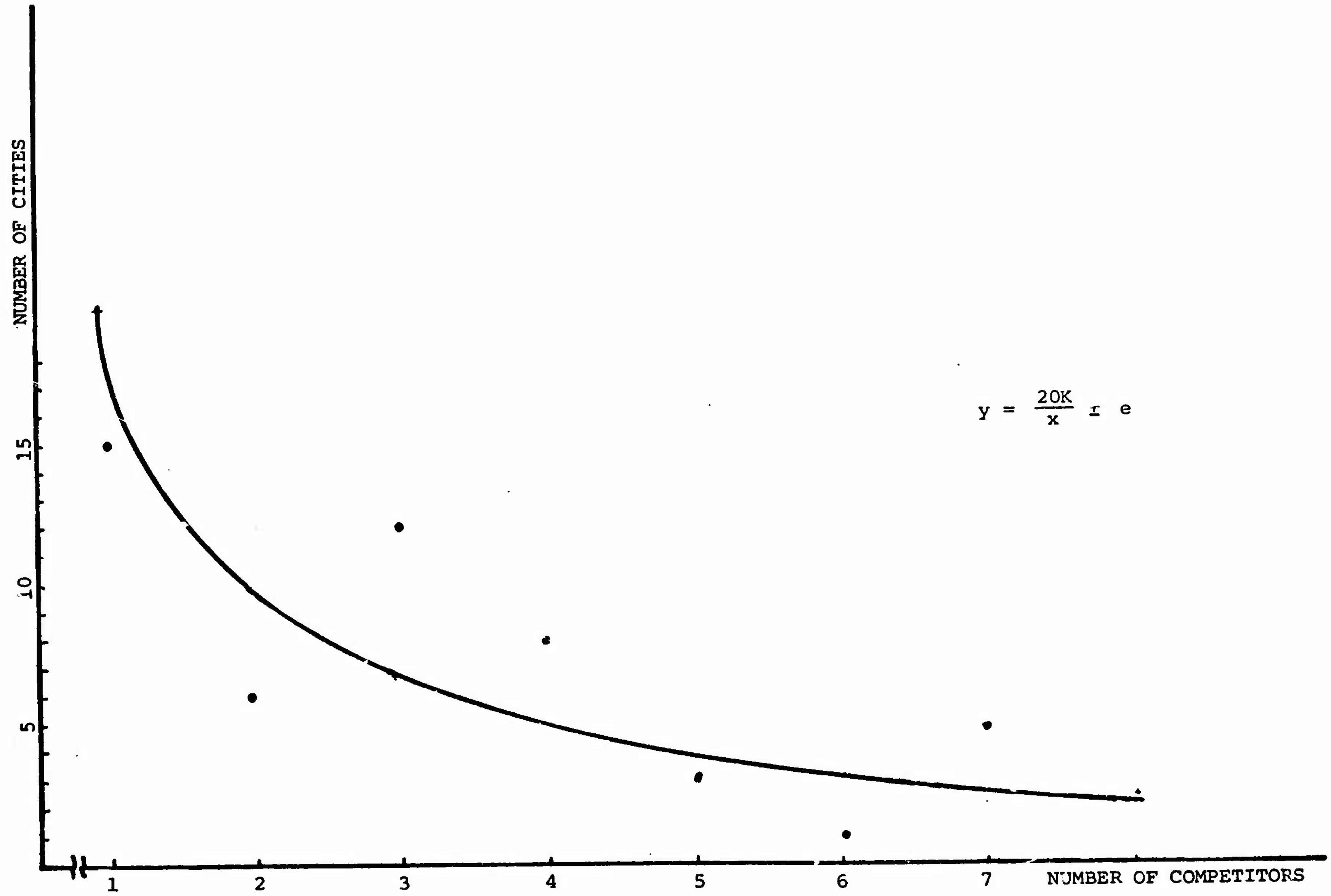


FIGURE B-3. PROJECTED NETWORK INSTALLATIONS, 1975

are still unresolved (supra). The existing carriers are opposed to entry and have raised the cost of entry to all except the rich or the very stubborn. As the venture capital dries up, and as the lines of credit are exhausted, the smaller companies are becoming less, not more, competitively viable. These are not healthy signs for those that prefer competition.

DUPLICATION BY DATA CARRIERS

A closer examination of Figure B-2 reveals the extent of the duplication. Twenty-two big city pairs are represented by more than one transmission line. Eleven city pairs are covered by two lines, four pairs are linked by three lines, one pair is covered by four lines, and six other pairs are covered by five, six and even seven parallel lines (see Table B-3). In all, the overall system shows fifty-two redundant city pairs -- transmission channels that add nothing to the overall network except cost. (See Figure B-4). Of course, two parallel identical trunks have twice the bandwidth of a single trunk. But most of the cost is in new routes; the incremental costs for added bandwidth is small. Thus, these fifty-two lines represent millions of dollars in potentially wasted resources. When faced with such evidence of inefficiency, the salient question hinges on the prospects of network interconnection. Will the firms realize that the most expensive part of their business, that is establishing new communication routes, is subject to dramatic cost savings if they would interconnect? Is there something innate in the free market system that will foster this sort of efficiency, and will the invisible hand tend to push aside the firms that resist the market forces?

Unfortunately, a fool-proof star gazing service is not yet in existence, and the writer is forced to draw on past observation of industry behavior if any light is to be shed on the question. Students of industrial market structure have repeatedly observed a phenomenon, which for lack of a better term became known as the Prisoner's Dilemma Game.*

----

* Scherer, pp 142 - 145.

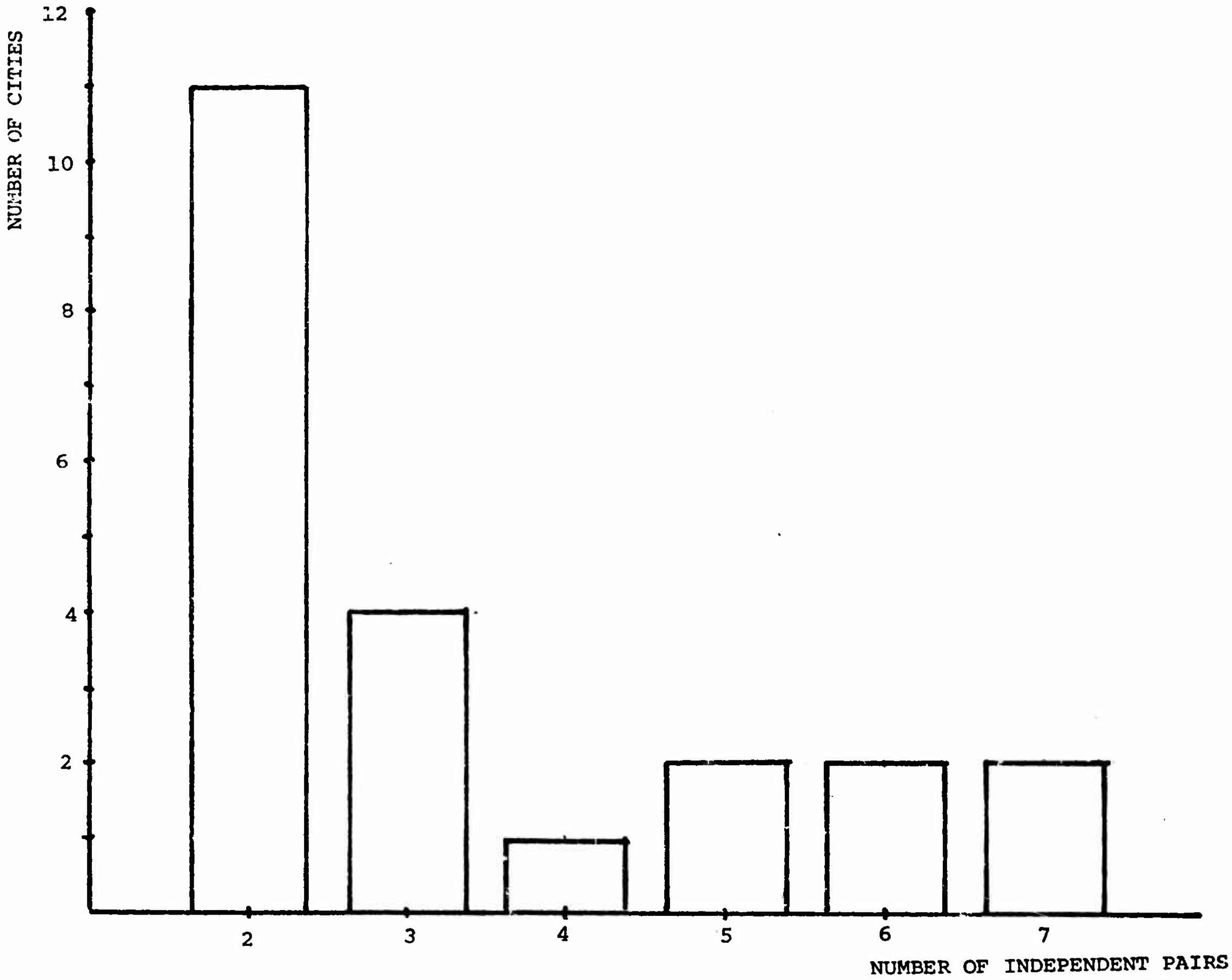


FIGURE B-4. NETWORK OVERLAYS (PARTIAL ANALYSIS)

The Prisoner's Dilemma

For the reader who is unacquainted with the original game, a description of its dynamics are in order. Mr. Able and Mr. Baker are charged with committing a burglary. The District Attorney is unable to prove his case unless he can obtain a signed confession; however, he is certain that he can obtain conviction on a lesser charge, possession of illegal wiretap equipment. The two suspects are interrogated in separate rooms and are given a choice of sentences. Able is told that if he confesses and spills the beans on Baker, he (Able) will get off scot free while Baker will get a ten year sentence. If they both confess (Able is not kept informed of all developments, of course), both will serve six years behind bars. If neither confesses, the District Attorney can guarantee that Able will spend at least one year in jail on the lesser charge. Naturally, Baker is given the same opportunities. These options very neatly form the elements of a minimax game, and one which has both a solution and a stable equilibrium. To demonstrate this point, the prospects of Able and Baker are presented in game matrix format:

Baker

Player / Move	Don't Confess	Confess
Able: Don't Confess	Baker 1-Yr (Optimal strategy) Able 1-Yr	Baker 0-Yrs Able 10-Yrs
Able: Confess	Baker 10-Yrs Able 10-Yrs	Baker 6-Yrs (Dominant strategy) Able 6-Yrs

Figure B-4. The Prisoner's Dilemma

From Able's point of view, if Baker does *not* confess, then Able can do one of two things: confess and go free, or not confess and, with Baker, get the one year penalty. If Baker does confess, then Able gets one of two outcomes: if Able also confesses, they both get six years and if he does not confess, he gets ten years in prison. Since Able is minimizing the number of years spent behind bars, his dominant strategy in both cases is *to confess*. Baker's choices are symmetrical, and he will also choose to confess. So, the dominant, stable outcome will net both men six years in prison, whereas we know that a non-dominant strategy -- namely, not to confess -- will have yielded both men only one year in jail.

<u>Application</u>

The Prisoner's Dilemma is a generic form of a game that appears constantly in industries dominated by oligopolies. The outcome of the game is that the dominant, non-optimal strategy is chosen by players who are trying to second-guess each other in favor of an optimal but non-dominant position that requires trust in the other player.

In terms of the main problem at hand, consider the following game:

	Firm II	
Player / Move	Interconnect	Don't Interconnect
Firm I: Interconnect to consortium of networks	10 (Optimal strategy) 10	14 6
Firm I: Don't Interconnect to consortium of networks	6 14	9 (Dominant non-optimal) 9

Figure B-5. Interconnection Strategy.
[Cell entry = Profits (π).]

From Firm I's point of view, he faces two outcomes. If Firm II decides to interconnect with a nationwide consortium of networks, he can either join the consortium (profits = 6) or hold out and fight for a market share against the entire consortium (profits = 14). If Firm II chooses not to interconnect, then it would be a high mortality struggle, if Firm I also chooses not to interconnect (profits = 9), or Firm I could choose to enter the relatively calm world of the consortium (profits = 6). From Firm I's perspective, not interconnecting with the consortium is a dominant strategy, as it is also from Firm II's perspective. The game, then, has a solution and an equilibrium: the firms *will not* interconnect, hence achieving profits of 9 units apiece. A non-dominant but optimal strategy was available -- to join the consortium -- but it was not taken because of distrust of the other fellow's motives.

A critical assumption built into the Prisoner's Dilemma game is that cell 1 (non-dominant interconnect) yields higher industry profits than cell 4 (dominant, no interconnect); it deserves further discussion. The present trajectory forecasts the development of an oligopolistic industry (supra). The pricing pattern in such industries is characterized by extreme sensitivity by each firm of the others' pricing decisions, especially with reference to the pricing leader.

The Missing Institutional Arrangement

The underlying argument for encouraging interconnection is that it eliminates inefficiencies and permits the industry to grow more rapidly and provide increasing services to the public. The bigger the pie, the bigger the piece that each entity could theoretically own. The question is whether it is possible to make it worthwhile for the individual entities to concentrate moving together as an industry in their common interest or whether their resources are better spent in duplicating one another's facilities in the larger cities and holding monopolies in the smaller ones. This question may already be answered in the overall digital communications industry. But, the opportunity for the packet switching industry to avoid some of these problems is clear. And, as it is in the interest of ARPA to provide itself with access to the largest effective digital communications network with the properties of a packet switching network, it is in the interest of ARPA to encourage the packet switching industry to cooperate with itself in having the industry evolve in a direction most desirable in ARPA's and the country's interest.

Choice of Name. The challenge that we address below is finding a way to encourage the data communications industry, or at least the packet switching component of the industry, to work together to achieve the maximum industry economy of scale, and to do so in as fully competitive a manner as possible. We shall describe a mechanism, consider its operation and then consider its results. We do not know the ideal name to attach to the proposed new institution. It could be called an industry trade association; it could be called a non-profit coorporation; it could be a farm-cooperative arrangement; or it could be any one of a large set of other institutional possibilities. For the sake of convenience, we shall call the required insitution a "consortium." But, the reader should regard the word more as an adjective than a noun. The exact form of the organization is secondary to its functions. And it must perform exactly three separate functions: free entry, universal interconnection, and a payment clearinghouse to administer shared costs.

The discussion of the consortium is divided into two parts: the mechanics and the economics of the consortium. Below we briefly describe how the consortium works. Then we discuss the economics. And, lastly, we consider the detail mechanics in a separate Appendix section.

Entry. Guaranteed free entry into the organization by potential competitors is a fundamental attribute. If any artificial barriers to entry can be erected, either at the inception of the consortium or at some later point in its development, then the initial purposes will have been undermined. Any packet switched network wishing interconnection into the consortium should be allowed entry, subject only to a minimum set of conditions that protect the established members from harm. For example, if an applicant is financially unstable and cannot be expected to fulfill its obligation under the payment

clearinghouse arrangement then the application should be legitimately challenged. A reasonable compromise in such an event could be the posting of a covering insurance bond.

Universal Interconnection. The ability to interconnect is critical to the formation of a combined network operated cooperatively by independent packet switching networks. The technical feasibility of interconnection seems assured, but will require the mutual agreement and cooperation of the networks involved to build suitable gateways through which packets may pass from one network to another. Strategies which have thus far been explored seem to require either that protocols at the packet switch level be fully compatible, or that a basic host to host protocol be mutually agreed upon which can use the various different packet switching systems simply as transmission facilities. Since the former requirement cannot be met (at least among current international networks), the latter requirement appears to be the only other immediate solution. The area still needs research and experimentation and effort in this direction will be spurred on by the formation of a consortium for interconnection.

Payments Clearinghouse. In the cases where a user traffic is routed exclusively through one network, no inter-network payment scheme is needed. The customer is billed in a straightforward manner, according to the firm's normal pricing structure. However, in cases where a customer's point-to-point requirements cause traffic to flow through a gateway, and into a neighboring network (or two or more), a revenue sharing scheme is needed to reconcile the usage. A payment clearinghouse is such a device.

A method of managing a payment clearinghouse is to keep an inventory of packets flowing from a member network, and computing a credit-debit sheet for each member. A packet-by-packet count is not needed. Telephone companies, for example,

use statistical sampling for determining "separations" as it is sometimes called.

A network which drew heavily on other members would be in a continual deficit position. In the structure of independently-owned subnets that we are considering, we find economic signals occurring here to cause that network to rearrange its topology with the objective of minimizing payouts. Every network can be characterized by several parameters: peak and average delay, peak/average reliability, and peak/average traffic flows. In a companion Appendix E, "Independent Nodes Economics Simulation Model," we have considered the contribution each component of a network makes to the effectiveness of the entire network. The computation of such a measure was achieved by eliminating one node from the network in an iterative fashion, and examining the impact on the system parameters listed above. Nodes that are efficient cannot be removed without a serious degradation of the overall system performance, whereas inefficient nodes (from a topological point of view) can be removed with either no impact on the overall system, or a net improvement in the overall system behavior. Therefore, a payment clearinghouse arrangement could serve a dual purpose: first, it could facilitate the formation of a resource sharing consortium by allowing networks to utilize each others' facilities at a fair price, and second, it would be a constant incentive <u>and source of information</u> for every member of the consortium to experiment with their topology and find the most efficient configuration.

Appendix C

ON FORMATION OF A COMMON INTEREST CONSORTIUM OF PACKET SWITCHING ENTITIES

by

MARC U. PORAT

C

PREFACE

This appendix is written to encourage a more detailed discussion of the operation of a hypothetical packet switching consortium; how it might function; how it might go about resolving differences; how it would provide the clearinghouse function; how it would assure open entry; and how it would create and enforce standards.

The intent here was to create an existence proof. Here is one way of doing the job. And, it seems to work. Therefore, there are no reasons to believe that a workable structure cannot be built.

In the following, the language has a certain "guardhouse lawyer" quality about it. This does not mean that this is a carefully prepared legal document. It is not. Rather, it is just an attempt to try to list the major contingencies in a formal manner; nothing more is intended or should be inferred.

TABLE OF CONTENTS

1.0 THE CONSORTIUM

1.1 NAME

The name of this organization shall be the Packet Network Consortium or "Consortium" in this report.

1.2 ORGANIZATION

The Consortium shall be a non-stock, not-for-profit corporation incorporated in the State of Delaware.

1.3 PURPOSE

The purpose of this Consortium is to encourage the development of the digital packet-switching capabilities in the public interest of the U.S., facilitating inter-network exchange of data and services and encouraging individually owned and operated packet-switched systems to be interconnected freely.

1.4 SCOPE

The Consortium shall have the right to enter into contracts, invest its funds in short term securities and engage in all other actions normal and appropriate to a not-for-profit corporation. It shall not have the right to incur debts beyond its current assets. In the event of dissolution, all assets will revert either to a not-for-profit organization chosen by the Board or to the Federal Treasury.

1.5 LIMITS OF SCOPE

While the Consortium is concerned with the general well being of the industry, its scope shall be restricted solely to matters affecting two or more separately owned packet-switching networks. The Consortium shall have the right to set and enforce inter-network standards and agreements between Members and to protect the rights of the consumer with respect to services offered by any Member that can negatively affect the well being of the industry.

1.6 MANAGEMENT

The Chief Executive Officer is the Chairman of the Board who is a Member of the Board of Directors and is elected by the Directors (See Figure 1).

The board is responsible for resolving major disputes and questions affecting membership status and matters affecting the public interest. The Board is selected by the Members voting in proportion to their dues paid or contracts issued in the field of packet networks.

The dues payable by each member will be in proportion to the annual gross revenue derived from packet services.

The Members Committee is a forum for expressing the interests of the Members to the President in which each Member has a single vote.

The President serves as chairman of the Members Committee and serves as Executive Director for the Consortium. He is responsible for day-to-day overall management, serving as Chief Operating Officer. He is appointed by the Board.

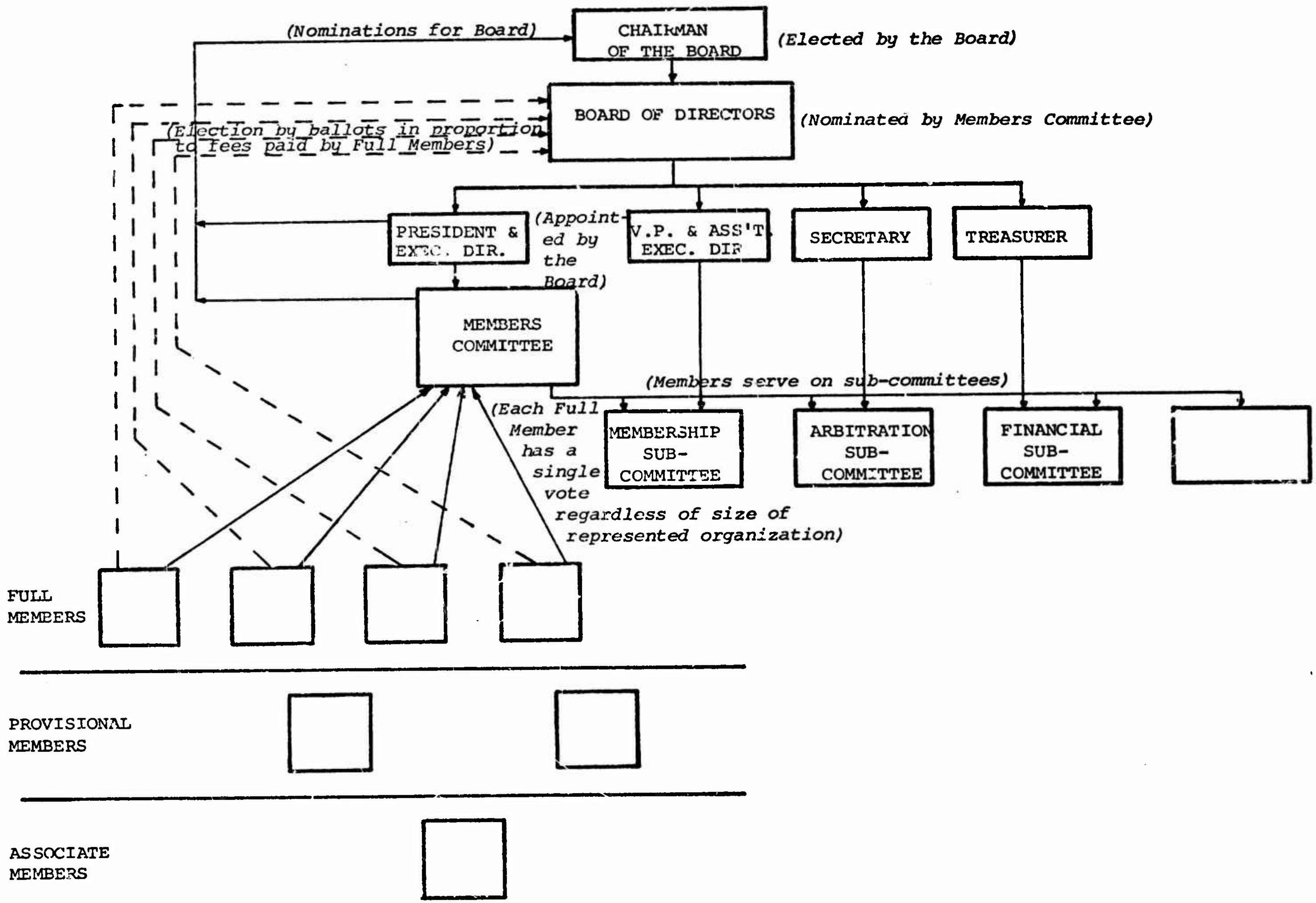


FIGURE 1. TABLE OF ORGANIZATION

Much of the work of the Consortium is carried on in Sub-committees organized by the Members Committee.

2.0 BOARD OF DIRECTORS

2.1 MEETING OF THE BOARD

The Board of Directors shall meet annually during the first week of February at the offices of the Consortium or at such place within the United States as the Board may determine, or may meet by conference telephone call. Additional meetings may be held at any time by majority choice of the Board, but all Directors shall be informed at least three weeks in advance, by telephone or by SNDMSG mail, of the schedule for such meetings.

2.2 DUTIES OF THE BOARD

The Board of Directors shall have power to change the by-laws of the Corporation; to appoint the President, Vice President, Secretary and Treasurer; and to set the salaries and terms and conditions of all officers. The Board shall serve as a final arbiter for all applications for membership to the Consortium and all other matters not resolved by the Membership Committee.

2.3 COMPOSITION OF THE BOARD

The Board shall be composed of nine members, initially representing the public sector, and in no case shall there be more than four who may be from companies supplying packet communications services and no more than two from government service.

2.4 SELECTION AND TERM

The initial Board of Directors shall be:

One year appointments:

1) [to be specified later]

2) "

3) "

Two year appointments:

4)

5)

6)

Three year appointments:

7)

8)

9)

The term of office for other than the initial Board shall be three years. No Board member may serve more than two consecutive terms without being off the Board for at least one year. The Chairman of the Board shall be a member of the Board and be chosen by the Board at its annual meeting. He shall serve as Chairman for a period of one year.

2.5 VACANCIES

Any vacancy in the Board of Directors shall be filled for the balance of the present term by a majority vote of the remaining Board at the next scheduled Board meeting. Board members may resign at any time by written notification to the Chairman.

2.6 REMUNERATION

The Board shall set the salary and other considerations for the officers of the Consortium. No salary shall be paid to the directors except in remuneration for direct expenses incurred in service and token honorarium for attendance at meetings.

2.7 FISCAL YEAR

The fiscal year shall coincide with the calendar year.

3.0 OFFICERS OF THE CONSORTIUM

3.1 SELECTION AND TERM

The officers shall be selected by the Board of Directors and serve at the pleasure of the Board.

3.2 PRESIDENT

The President shall be the Chief Executive Officer of the Consortium and shall normally serve as chairman at the meetings of the Membership Committee. He shall conduct all other duties as defined in the By-Laws.

3.3 VICE PRESIDENT

The Vice President shall serve as Acting President in the absence of the President and shall be responsible for all other duties assigned by the Board or the President. He shall also serve as Chairman of the Management Services Subcommittee.

3.4 TREASURER

The election of the Treasurer shall take place on the first meeting of the Fiscal Year. The Treasurer shall serve as chairman of the Finance Subcommittee and shall be responsible for performance of that Subcommittee.

3.5 SECRETARY

The Secretary shall affix the seal of the Corporation on all documents and contracts as required by law and shall serve in any other capacity as defined by the Board or the President.

3.6 RESIGNATION

Officers may resign only upon due written notice to the Chairman of the Board in conformity with the terms of their employment agreements.

4.0 RULES OF ENTRY INTO THE CONSORTIUM

4.1 GRADES OF MEMBERSHIP

There are several grades of membership in the Consortium.

Full Membership is normally restricted to owners of packet-switched networks that interconnect with others.

Provisional Membership is the grade of membership for representation from organizations that meet essentially all of the requirements for Full Membership but are deficient in some specific major regard. Normally the Provisional Membership status lasts 90 days, in which it is anticipated that the deficiency will be corrected, and Full Membership status restored. A 30 Day Provisional Membership state is used for the case of an organization expected to terminate its connection to the Combined Network.

Associate Membership is used for observers and other individuals not normally affiliated with an organization owning a connected network.

Subnet Member includes representation of organizations that in and of themselves do not constitute a full network requiring enroute packet-switching for others. Examples would include an organization owning only a Host computer; or an organization owning only a TIP serving a single geographical area.

Table 1 describes the rights and responsibilities of the

TABLE 1

RIGHTS AND RESPONSIBILITIES OF VARIOUS GRADES OF MEMBERSHIP

	Subnet Member	Associate Member (Observer)	90 Day Provisional Member	Full Member	
Full Voting Right	no	no	no	yes	RIGHTS
Right to Attend Meeting	yes	yes	yes	yes	RIGHTS
Serve on Subcommittees	yes	yes	yes	yes	RIGHTS
Non-obligatory right to interconnect	yes	NA	yes	yes	RIGHTS
Right to interconnect - general	no	NA	no	yes	RIGHTS
Access to Management Services	yes	no	yes	yes	RIGHTS
Participate in revenue-sharing agreement	yes	NA	yes	yes	RIGHTS
Contract with Hosts for services	yes	NA	yes	yes	RIGHTS
Right to change, add or delete components that affect the Combined Network	yes	NA	no	yes	RIGHTS
Meet all conditions for Full Member (not including performance standards)	no	NA	yes	yes	RESPONSIBILITIES
Meet full performance standards	NA	NA	no	yes	RESPONSIBILITIES
Own full independent network	no	no	yes	yes	RESPONSIBILITIES
Own partial network that cannot work without interconnection	yes	no	NA	no	RESPONSIBILITIES
Meet reliability and full performance standards	yes	NA	no	yes	RESPONSIBILITIES
Pay dues of 1% of gross revenue	yes	no	no	yes	RESPONSIBILITIES
Pay $200/year	no	yes	no	no	RESPONSIBILITIES
Attend 75% of meetings of Members Committee	no	no	no	yes	RESPONSIBILITIES

various grades of membership. These rights and responsibilities are described in more detail in the following sections.

4.2 APPLICATION FOR MEMBERSHIP

Each prospective Full Member of the Consortium must formally apply for membership and fulfill the following requirements to gain entry. (See Figures 2A and 2B for hypothetical application forms which suggest the form of the information sought.)

4.3 CREDENTIALS

Demonstrate financial, technical, and managerial capability.

Each prospective Full Member shall show, through a documented presentation, that it is capable of providing better than the minimum allowable quality of service. Evidence should include: an audited recent financial statement presented to the Financial Subcommittee; a detailed statement of prior or present activity in a related technical field, or, acquisition of a technical staff to assure technical competence, presented to the Performance Standards Subcommittee; presentation of an organization chart delineating major areas of responsibility with respect to Consortium membership and obligations, presented to the Membership Subcommittee.

4.4 CONTRACTUAL CONSENT

All members are bound to perform pursuant to the rules and regulations of the Consortium, except in such cases as the Board elects to grant special exemptions or privileges to a member upon the discovery and proof of extraordinary circumstances. Failure to abide by Consortium rules and regulations shall cause Full Member status to be reduced to 90 Day Provisional Member-

PACKET NETWORK CONSORTIUM

APPLICATION FOR FULL MEMBERSHIP

1. Full operating name:
2. H.Q. Address: Tel. #
3. Name & Address of all affiliates, branch offices, etc:
4. Parent organization; Name:
   Address:
   Telephone:
5. Type of organization:
6. Statement of purpose:
7. President:
8. V.P. Operations:
9. V.P. Marketing:
10. Technical manager:
11. Appendices: Corporate Charter & By-laws ☐
    Most Recent Financial Statement and Annual Report ☐
    Interconnection Standards ☐
    Facilities Certification ☐

FIGURE 2A, APPLICATION FOR FULL MEMBERSHIP, page 1

As duly authorized representatives of ____________________,

we petition the Packet Network Consortium for

- ☐ Full
- ☐ Provisional
- ☐ Associate
- ☐ Sub-net

Membership, and in recognition of the rights and benefits derived therein, agree to fully abide by the rules and regulations of the Packet Network Consortium as defined in their Charter and By-laws, as effective on this data as may be modified.

We certify that the gross annual revenue of our organization related to packet communications was $________ before expenses and taxes. Enclosed herein is the greater of one percent of that amount or $300.

Amount attached: $________

____________________ President	________ Date
____________________ Secretary	________ Date

FIGURE 2B, APPLICATION FOR FULL MEMBERSHIP, page 2

ship or disqualified from membership.

4.5 OBJECTIONS TO ENTRY

Upon submission of all necessary credentials by a prospective Consortium Member, any Full Member may raise an objection, grievance or request to bar entry on the following show cause grounds: the prospective member has not demonstrated good faith in previous dealings with a member of the Consortium; and/or the prospective member has failed to demonstrate financial, technical or managerial capability; and/or the prospective member declines to abide by the rules and regulations of the Consortium; and/or the prospective member's location in the Combined Network threatens to seriously degrade the overall network performance.

4.6 MOTION TO BAR ENTRY

A prospective application for Full Membership may be barred or reduced to 90 Day Provisional Membership by a two-thirds (2/3) vote of the Members Committee. A prospective applicant who is thus barred from entry into the Consortium as either a Full or 90 Day Provisional Member may either re-file the application after a ninety-day (90) period without prejudice or appeal the decision to the Board of Directors to be heard at their next scheduled meeting. The decision of the Board will be binding and if entry is barred, no further application from the applicant will be accepted for one year. (However, the prospective member is always free to take court action if he feels that the decision is unfair.)

In the event that a Motion to Bar Entry is raised by a Consortium member, the Members Committee may, by a majority vote, elect to stay the application for a thirty-day (30) period. During this period, the substantive issues raised by the Motion to Bar Entry will be studied by the Membership Subcommittee and a recommendation of action provided to the Members Committe for their review and vote.

5.0 MEMBERSHIP IN THE CONSORTIUM

5.1 FULL MEMBER RIGHTS AND DUTIES

Upon entry into the Consortium as a Full Member status, the Member is granted the following rights: full voting membership in the Members Committee meetings - a Full Member may hold an office in the Packet Network Consortium; right to join subcommittees of the Coordinating Committee; right to subscribe to all management services supported by the Consortium and to join in all activities, experiments and conferences sponsored by the Consortium; right to interconnect to any or all nodes in Full Members' network subject to technical standardization considerations; right and obligation to partake in revenue separation agreements; right to enter into contract with any Host for services; right to add or delete IMPS or TIPS or communications links.

The duties and obligations of Full Members shall include: attendance at not less than seventy-five percent (75%) of all Members Committee meetings during the twelve-month period following entry into the Consortium, and each subsequent twelve-month period; agreement to support the Consortium by prompt payment of membership dues. Dues shall be payable in pro-rata monthly installments. Being in arrears in excess of sixty (60) days shall cause the Full Member status to be downgraded to Provisional Membership.

5.2 PROVISIONAL MEMBER RIGHTS AND DUTIES

The Provisional Member status is granted a limited set of rights consisting of: right to attend all meetings of the Members Committee open to Full Members; right to join subcommittees of the Coordinating Committee; right to subscribe to management services supported by the Consortium and to join in activities, experiments and conferences sponsored by the Consortium; right to interconnect to any node in the Consortium subject to a non-obligatory agreement by a Consortium member to interconnect.

A Provisional Member is bound by the same duties and obligations outlined with respect to attendance and payment of dues.

Provisional Member status is granted to a member by a majority vote of the Members Committee in the event of the following: a Full Member requests such status; and/or a Full Member fails to meet the minimum performance standards; and/or fails to meet the fee payment schedule; fails to abide by the Interconnection standards; defaults on a cost-sharing contract with another Full Member; defaults on the inter-network revenue sharing arrangement.

The Provisional Member status expires after a ninety-day (90) period, at which time the Members Committee reviews the conditions of the Provisional Member. Should the conditions listed in the aforementioned sections not be rectified, the Members Committee may elect, by a simple majority, to terminate membership in the Consortium; or re-issue a 90 Day Provisional Member status. Such a re-issuance may be obtained a maximum of three times, at which point mandatory termination of membership occurs.

5.3 ASSOCIATE MEMBER

Any member of the Members Committee may nominate an individual affiliated with government, university, media, industry or any other concerned group or individual interested in being an observer to receive Associate Member status into the Members Committee meeting of the Packet Network Consortium. A motion to seat such a member shall be carried by a simple majority vote.

5.3.1 Rights and Duties

An Associate Member may attend all meetings of the Packet Network Consortium open to the Full Member, participate in all events and functions of the Consortium and join a Subcommittee of the Consortium. Such a member may not vote in the Members Committee except to cast an Opinion vote.

The membership fee for Associate members is $200 a year, non-refundable.

6.0 THE MEMBERS COMMITTEE

6.1 REGULAR MEETINGS

6.1.1 Date

Regular meetings of the Members Committee shall be held on the first Tuesday of each month. Except where the first Tuesday constitutes a National, state, or religious holiday; then the regular meeting shall be re-scheduled to the next available day, and a notice of such change shall be made by the Chairman of the Members Committee (the President).

6.1.2 Participants

All Full Members, Provisional Members, Associate Members and Subnet Members hold seats in the Members Committee. Only Full Members may cast Action votes in the Committee, but all members may cast Opinion votes.

6.1.3 Minutes

Minutes of the Members Committee meetings and of all subcommittees of the Members Committee shall be supplied at reproduction plus handling cost to all grades of membership. As a matter of policy all business conducted in the name of the Consortium, other than that relating to personal data, shall not be held from any other member of the Consortium or from the public. Violation of this article shall jeopardize the Full Member status,

and constitute grounds for termination of membership.

6.1.4 Procedure

All meetings of the Members Commitcee and Subcommittees shall use the parlimentary procedures under Robert's Rules of Order.

6.2 DUTIES OF THE SUBCOMMITTEES

The Members Committee shall form such subcommittees as defined in the various sections and articles of the by-laws, or as the need arises, or as requested by the Board of Directors.

6.2.1 Membership Subcommittee

To oversee the entry procedures and to issue a recommendation on each case.

6.2.2 Performance Standards Subcommittee

To oversee the reliability of the Combined Network, and to certify each Member's Down Time report, and to offer advice to the Members Committee on any technical issues which may arise from technical changes in the member networks.

6.2.3 Interconnection Standards Subcommittee

To oversee the protocols for interconnection and to offer advice to the Members Committee on issues arising from interconnection standards.

6.2.4 Finance Subcommittee

To certify each entry applicant's financial statement; to

assist Consortium Members in any cost and revenue sharing; to recommend changes in the membership fees; to collect dues; to oversee the financial operations of the Consortium; to review the annual balance sheet.

6.2.5 Arbitration Subcommittee

To arbitrate disputes between Members when both parties agree to arbitration. A Member will be disqualified from service by the Arbitration Subcommittee if any doubt should arise regarding conflict of interest or prejudice with respect to the disputing parties or the issue at stake.

6.2.6 Management Services

To oversee or negotiate the operations of all management services offered by the Consortium to its members and to act as liaison between the Members Committee and the management services operations.

6.3 MANAGEMENT SERVICES

The Members Committee shall provide certain management services open to all members of the Consortium as defined below or as subsequently defined by the Members Committee. The Members Committee shall be empowered to either staff such services or to contract such services out, pursuant to a recommendation by the Management Services Subcommittee.

6.3.1 Network Information Center

To post and publish all minutes, motions, reports, changes and other information relating to the activities of the Consortium, as defined in the by-laws or as subsequently defined by

the Members Committee. To maintain, preferably in machine-retrievable form, any documents submitted by the Committee relating to the operations of the Consortium or services offered by its Members.

6.3.2 Network Monitoring and Measurement Center

To monitor the operation of the Combined Network and detect malfunction in any component; to alert the members of the network in the event of a malfunction or disruption in service; to aid in repairing such a malfunction; to keep logs on traffic flows in the Combined Network, including performance data on reliability and delay time; to conduct experiments as requested by the Members Committee; and to make available all such data as a public record (upon request).

6.4 QUORUM

A legal quorum of the Members Committee shall be defined as a majority of all Full Members.

6.5 SPECIAL MEETINGS

A special meeting of the Members Committee may be called by the Chairman of the Board, the Presdent or by at least one-third (1/3) of the members of the Members Committee. All Members, except Associate Members, shall be notified at least ten (10) days prior to the actual date of a Special Meeting.

7.0 MINIMUM PERFORMANCE STANDARDS

All members, except Associate Members, of the Consortium shall maintain performance records as described below. The Consortium as a whole shall support a Management Service to evaluate the technical performance of each node. Maintaining a Full Member status in the Packet Network Consortium is contingent upon maintaining at least a minimum quality of service throughout all parts of the connected network that can affect the performance of the Combined Network (defined below). Regular reviews of each node's performance will be provided at each Members Committee meeting by the Consortium Management Service for network analysis. The target minimum quality of service is that the Combined Network (composed of all member networks) shall be operational twenty-four hours per day, every day of the year. The target reliability standard for the Combined Network [is to be defined]. Each member shall guarantee that its nodes fulfill all agreed to standards.

7.1 MAINTENANCE

Any individual Gateway, IMP (or equivalent) or TIP (or equivalent) may be taken out of service as required by routine or emergency maintenance, provided that the fractional amount of time involved in such maintenance shall not exceed five percent (5%) of all time, computed as follows:

[To be defined.]

7.1.1 Routine

Routine maintenance and program changes which interrupt

service shall take place only during published Scheduled Maintenance Period; the Performance Standards Subcommittee shall collect and publish such information during the regular meeting. The Scheduled Maintenance Period shall extend between 0100 and 0600 Eastern Standard Time.

7.1.2 Emergency

Any failure which interrupts on-going computation from any TIP or IMP occurring outside a published Scheduled Maintenance Period as defined in 7.1.1 shall be counted as Emergency Down Time. Emergency Down Time shall be measured from the first detection of failure until the failing unit is restored to full service. The duration of Emergency Down Time shall be multiplied by ten (10) when computing the time involved in maintenance discussed in 7.1 (See Table 2)

7.1.3 Transient

Any transient failure which interrupts on-going computation from any TIP or IMP for three (3) minutes or less shall be counted as a thirty (30) minute Down Time failure. Any transient failure longer than three (3) minutes shall be considered as Emergency Down Time as described in 7.1.2.

7.1.4 Modem

Failure of a single TIP input modem from the user shall count as a failure of one-tenth (1/10) its time duration in computing TIP statistics.

7.2 PERFORMANCE REPORT

7.2.1 Failure Statistics

Failure Statistics for each TIP and each IMP shall be prepared each month and certified as being correct. Signed copies

TABLE 2

PACKET NETWORK CONSORTIUM UP-TIME AND MAINTENANCE-TIME OUTAGE EQUIVALENTS		
Outage During Up-Time	Equals	Outage During Scheduled Maintenance Period
1 Minute	=	10 Minutes
6 Minutes	=	1 Hour
1 Hour	=	10 Hours

of the performance reliability report shall be sent to each Host installation attached to any part of the Combined Network, and to the Members Committee. The Member Committee shall publish such reports and make them available to all Consortium members.

7.2.2 Customer Complaints

All customer complaints received from any user concerning any component of the Combined Network, its agents or representatives, shall be compiled by the Performance Standards Subcommittee and entered as part of the operation record. Full text of such complaint records shall be made available, and shall be maintained by the Performance Standards Subcommittee and made available to all Consortium members.

7.3 EXCESSIVE OUTAGE

Excessive outage beyond the limits set forth in Table 3 may result in the downgrading of a Full Member to a Provisional Member status.

7.4 HOST CONNECTION

Any new Host wishing a new connection with a Full Member of the Consortium and have its service available to all users on the network shall be provided with access to an IMP within sixty days (60) from the time of issuance of a formal contract between the Consortium member and the intended Host. Upon the receipt of an Intent to Connect statement, the Members Committee shall post and publish a description of the Host (See Figure 3).

Upon publication of the Intent to Connect, any objections, modifications or grievances arising from such an intent may be brought to the Members Committee or to an Emergency Forum by any

PACKET NETWORK CONSORTIUM

APPLICATION FOR ADDING NEW HOST COMPUTER FACILITIES TO THE NETWORK

(a) Full Operating Name:

(b) H.Q. Address: Tel.

(c) Name & Address of parent organization:

(d) Name & Business address of:

(i) President

(ii) Vice President

(iii) Technical Manager

(iv) Liaison with Computer Network Consortium Member

(e) Log-on procedure at HOST site:

(f) Full list and description of services offered by HOST: (Attach)

(g) Price list of each service listed above: (Attach)

(h) Name of Consortium member(s) serving as a connection to the Combined Network:

FIGURE 3, HOST APPLICATION

TABLE 3

PACKET NETWORK CONSORTIUM

ALLOWABLE OUTAGE TIMES FOR ANY NETWORK
FORMING PART OF THE COMBINED NETWORK

	Hours
100% Up-Time (24 hours x 365.25 days)	8766.00
98% of Maximum Up-Time	8590.00
Maximum allowable outage	175.32
Allowable Down-Time (1 hour per)	365.25
TOTAL ANNUAL ALLOWABLE OUTAGE	540.57
Mean Daily Allowable Outage	1.48

Consortium member within fifteen (15) days after the publication date. The Members Committee or Emergency Forum may, by majority vote, elect to stay an application for a thirty-day (30) period on the following show cause grounds:

a) The intended Host has demonstrated bad faith in previous dealings with a member of the Consortium.

b) The intended Host has demonstrated technical incompetence in previous dealings with a member of the Consortium

c) The intended Host's connection will degrade the technical performance of the Combined Network.

Upon the termination of the thirty-day period (starting on the day of receipt of the Intent to Connect statement), the intended Host shall be connected.

Failure to so comply, barring extraordinary technical failures, may jeopardize Full Member status in the Consortium.

8.0 STANDARDS FOR INTERCONNECTION

The Packet Network Consortium shall create and support a subcommittee for Interconnection Standards. The functions of the subcommittee are:

a) To insure interconnection standards between all members of the Consortium via at least one Gateway each.

b) To agree upon standards for inter-network protocols, specifically at the Host-Host and basic process-process level.

c) To join in protocol experiments leading to more efficient use of the Combined Network.

d) To certify all prospective Full Members' facilities with respect to system compatability such that overall network performance will not suffer degradation.

8.1 HOST-HOST PROTOCOL

[To be specified.]

8.2 PROCESS-PROCESS PROTOCOL

[To be specified.]

8.3 CERTIFICATION OF FACILITIES

[To be specified.]

9.0 COSTS AND REVENUE SHARING

All Members, except Associate Members, of the Consortium are eligible for cost sharing arrangements. Such arrangements are completely optional and are negotiated on an individaul case-by-case basis by the Consortium members involved.

9.1 LEASED LINE COSTS

Exclusively intra-network leased lines are the responsibility of the individual Consortium members. However, whenever a leased line connects two or more gateways, the parties in question may split the cost of that line. The cost-splitting formula may be negotiated in any way that is deemed satisfactory to the Consortium members in question, e.g., pro-rata traffic flows, pro-rata projected traffic flows, etc.

9.2 JOINT VENTURES

Any member of the Consortium is free to engage in a joint venture with other members of the Consortium. The joint venture may include hardware acquisition (e.g., satellite link) or service and marketing (e.g., acquisition of Host or TIP facilities).

9.3 MANAGEMENT SERVICES

All Consortium members may utilize the available management services, the cost of such services approximately in proportion to membership fees paid.

9.4 INTER-NETWORK TRAFFIC

Revenue-sharing arrangements occur in the case of inter-network traffic flows, i.e., use of facilities belonging to one Consortium member by another Consortium member. Each member's gateway node performs an accounting function to keep track of packet-origin. At the close of the monthly billing period, a statement is issued by each member (See Figure 4).

The monthly statements are processed by the Consortium and any accounting errors or anomalies are resolved. The Consortium processes the statements and issues a bill to each member (See Figure 5). Failure to reconcile all debts to other Packet Network Consortium members is defined as forty-five (45) day arrears, and may result in downgrading membership to Provisional status.

PACKET NETWORK CONSORTIUM

INTER-NETWORK ACCOUNTING FORM

BILLING PERIOD:______________________________

MEMBER NUMBER:_______________________________

PACKETS TO
MEMBER NO.

PACKETS FROM MEMBER NUMBER	1	2	3	.	.	.	n
1	-						
2		-					
3			-				
.				-			
.					-		
.						-	
n							-

FIGURE 4, INTERNETWORK ACCOUNTING FORM

PACKET NETWORK CONSORTIUM

MONTHLY RECONCILIATION STATEMENT

BILLING PERIOD: ______________________

MEMBER NUMBER: ______________________

To (From) Member No.	Adjustment Credit (debit)
1	
2	
3	
.	
.	
.	
n	

FIGURE 5, MONTHLY RECONCILIATION STATEMENT

10.0 TERMINATION OF MEMBERSHIP

10.1 ESTABLISHING A NEED FOR TERMINATION

Need for termination is established by several methods. Each has a time limit associated with it to facilitate any transitional difficulties that may result from termination.

10.1.1 Member-Requested

Any member may, upon receipt by the Members Committee, terminate Consortium membership after a thirty-day (30) period. The Members Committee, upon receipt of such an Intent to Terminate notice, shall post and publish the details of the termination.

10.1.2 Network Consortium-Initiated Termination

Any Consortium member may initiate termination proceedings against another member if:

a) That member has held a Provisional Member status for a period not less than ninety days (90).

b) That member has been convicted in a court of law in a proceeding involving the operation of the Packet Network Consortium or adversely affecting the operation of a Consortium member.

Termination under the above circumstances shall be effected by a simple majority vote of the Members Committee.

10.2 30 DAY PROVISIONAL STATUS

A 30 Day Provisional Member status is assigned to a Consortium member, and after thirty days (30) all connection with the Provisional Member is severed.

10.3 TRANSFER OF OWNERSHIP

Membership in the Consortium is not transferable by sale, lease or grant. In the event of a transfer of ownership the new owner shall petition the Consortium for entry in the normal manner.

Appendix D

A DELPHI EXERCISE EXAMINING FOUR ALTERNATIVE COMMUNICATIONS POLICY OPTIONS

by

MARC U. PORAT

D

PREFACE

This appendix is a work product generated during a period of discussions about completely different ways that ARPA might go about solving its problems of pressures for growth of the ARPANET.

This particular piece was a Delphi interrogation of the staff during its discussions. It is included partly for historic reasons, and partly because it shows that alternative industry structures were considered before acquiring a fixation on the single final suggestion that is examined in detail in this larger report.

Since this Delphi discussion took place almost six months ago, much discussion has taken place and what is called the "NCCN" is now generally referred to as "the combined network."

INTRODUCTION

During two weeks in August 1973, the Cabledata Associates' research staff engaged in an informal Delphi on the question of ARPANET's future. The staff explored several possible directions for divestiture, each of which might lead to a markedly different future for the computer-communications industry as a whole.

Following a preliminary discussion to set the scope of the study, the group participated in the first iteration of the Delphi. The original five scenarios were collapsed and redefined into four scenarios, as presented in the report. The group acknowledges that the description accompanying the scenarios is necessarily vague by virtue of the broad scope of the context. However, the aim of the Delphi was more to interchange our own thinking on the subject in a systematic manner rather than any attempt to forecast a future. It was successful in stimulating debate and compelling the group to develop a common language.

METHOD

The four scenarios were discussed by the group until agreement was reached on the definitions of the evaluative terms. The writer attempted to capture this image in the form of a brief descriptive summary.

Each of the scenarios was then evaluated by the participants with reference to fifteen criteria items. An explication of the evaluation criteria was included in the Delphi package and is shown in the next section of this paper followed by the definition

of the rating metric.

The group then discussed the outcomes with the aim of reconciling (or at least airing) the major differences.

DEFINITION OF CRITERIA ITEMS

"The computer-communications industry is assumed to develop under the stated scenario such that by 1978, the (criteria item) will be rated (supply rating 1...5)."

Reliability

Service will not be unduly interrupted, a customer can expect error-free, delay-free service on call. High capital investment. good technology, good management, responsive to changing demands.

Equality

Neither the purveyors nor the customers suffer discrimination; or, both purveyors and customers are equally on the short end of the stick.

Innovativeness

New hardware, software, organizational ideas are diffused and implemented quickly. Change and experimentation are encouraged, not hindered.

Stability

When change occurs, it does not result in disruption of the operating system; long-range planning is possible from the customer point of view. Next month will seem like this month.

Rate of growth

Of traffic, information services, etc., compared to the other scenarios.

Ability to raise capital

The industry looks profitable: venture capital is attainable, and stock offerings will be well-recieved.

Speed of raising capital

The P/E ratio starts high, stays high.

Implementability

Organizational: the management structure is sufficiently familiar (or disguisable) that an organization can be efficiently formed and launched.

Implementability

Technical: the technical issues can be resolved -- not waiting for state-of-the-art breakthrough.

Implementability

Legal: the scheme won't encourage intra-industry lawsuits, anti-trust actions, FCC heel-dragging, Congressional eyebrow raising.

Implementability

Political: toe-stepping can be kept to a minimum; special interests won't be fatally offended; powerful enemies will not be

incurred. The political process will encourage the scenario.

Implementability

Social: the scenario will receive no press or good press; consumer groups will be in favor of it; the public reaction will be favorable. Good PR.

Social welfare

The scenario will pull society in a desirable direction -- good national policy, high utility in the long run.

Privacy

System hard to tamper with, reasonable standards of privacy can be assured.

Probability of occurrence

Given everything, what are the real chances that the scenario will occur.

RATING METRIC

1. Terrible; worst of all possible outcomes. Almost nothing good to say about it.

2. A real problem; worse than today's conditions. Major overhaul required in this area.

3. About the same as today; acceptable with complaints. Lots of room for improvement, but functioning.

4. Quite good; no major flaws or complaints. Definitely not a

a problem area. Attention and resources could be turned to other matters.

5. Excellent; best of all possible outcomes. Almost nothing bad to say about it.

FOUR SCENARIOS

SCENARIO I: BUSINESS AS USUAL

The game is played by the old rules in the usual manner. Computer/communications networks are classified so as to fall partially under government common-carrier regulation. The industry splinters along regulatory edict lines, such as:

a) Virtually unregulated, "hybrid data processing," with message switching incidental to data processing. Example; Tymnet.

b) FCC regulated, "hybrid communications" with data processing incidental to message switching. Example; PCI.

The industry structure aligns to primarily fit the regulatory constraints rather than the market-place. All technical issues and tariffs in the regulated case are argued individually. The OTP, NBS, GSA become heavily involved in setting the government policies with respect to the new industry, especially in government purchasing.

SCENARIO II: POST OFFICE/COMSAT

A Public Information Utility Corporation is set up by Congress after Executive Department request. It is funded partially by the government, by common carriers, and by stock offerings. Any user may have access to the net if he pays the tariff. A user may be a private individual, a private company, a branch of

government, an information utility service, or one of the hybrid computer communications companies. Private nets attach to and have access via the PIUC network. The PIUC raises its own capital, and invests it as it sees fit, e.g., creating satellite links, leasing ATT lines, buying IMPS, etc. Competition between firms using the PIUCNET is possible and is encouraged. Legislation is enacted to ensure privacy.

SCENARIO III: NATIONAL COMPUTER COMMUNICATIONS NETWORK (NCCN)

The National Computer Communications Network (NCCN) is established as a non-profit association. It is composed of competing entities, each of whom offers an information service. These components of NCCN take on disparate forms, such as:

a) HOST centers with powerful general computing facilities.

b) Small HOST centers offering a specialized information utility.

c) TIP operators who perform the local marketing and local customer hand-holding service functions.

d) Franchise sub-nets which lease IMPS, TIPS, and/or HOSTS to individual entrepreneurs.

e) Support companies which help the components in technical, managerial, marketing problems.

All members in NCCN agree to abide by a charter, and have an active role in changing the charter. When a new membership is approved, the member agrees to abide by NCCN rules. The NCCN serves in three functions:

1) An entry/exit mechanism for its components and an information center.

2) Guarantee interface standards between components or sub-nets.

3) Provide a revenue-sharing function according to the contribution of each component to the whole network.

Line-leasing, marketing, management, accounting, etc. are generally left to the member components. The NCCN operates on a minimum budget raised by levying a fee on each of its members.

SCENARIO IV: ADAM SMITH PLUS BIG STICK

The government's regulating of the industry is minimal, primarily via enforcing anti-trust statutes. A free market develops and flourishes, with small and large companies coexisting and flourishing.

The government centralizes its purchasing under one roof, and becomes a significant customer on the market-place. It wields considerable leverage in forcing interconnections between networks using such powers as boycott, subsidy, and anti-trust threats.

Monopolistic contours do not take form in the industry leaders; free entry to the industry remains possible; cross-subsidization and price-fixing do not occur.

TABLE 1

THE FOUR SCENARIOS

Group Measures (N=5)

Evaluation Criteria	I Business As Usual	II Post Office-COMSAT	III NCCN	IV Adam Smith & Big Stick
1. Reliability	3.2	3.4	3.4	3
2. Equality	2.8	3.6	4.2	3
3. Innovativeness	1.8	2.2	4.2	3.8
4. Stability	2.4	3	3	2.6
5. Rate of growth	2.4	2.8	4	3.2
6. Ability to raise capital	2.8	3.2	3.2	3.2
7. Speed of raising capital	2.4	2.8	3	2.8
Implementability				
8. ...organizational	3.8	2.4	2.4	3.2
9. ...technical	3.4	3	3.4	3
10. ...legal	3.4	1.6	2.4	2.6
11. ...political	3	1.2	2.6	2.8
12. ...social	3.2	2	3.6	2.6
13. Social welfare	2	2.8	4.2	2.8
14. Privacy	2.6	3.4	4	2.6
15. Desirability (overall)	2	2.8	4	3
PROBABILITY OF OCCURENCE:	.44	.1	.22	.24
$\sum N_i/15$	2.746	2.688	3.600	2.946
$p.(\sum N_i/15)$	1.208	.268	.792	.707

GROUP JUDGMENT

While the rankings by the group are perhaps overly more indicative of the internal value systems of the individual respondents, they do provide some insights into the existence of consensus.

IN SUMMARY

The Most Desirable Outcome: NCCN ($\bar{x} = 3.6$)

The Most Likely Outcome: Business as Usual ($p = .44$)

The Least Desirable Outcome: Post Office/COMSAT ($x = 2.7$)

The Least Likely Outcome: Post Office/COMSAT ($p = .1$)

The group's preference for Scenario III (NCCN) was clearly expressed. The NCCN Scenario received highest ranking or tied for highest ranking in twelve out of fifteen criteria items. The following chart outlines its areas of strength and weakness.

Scenario III: National Computer Communications Network

Strong Areas	Weak Areas
Equality	Organizational Implementability
Innovativeness	Legal Implementability
Rate of growth	Political Implementability
Social implementability	
Social welfare	
Privacy	
Overall desirability	

The NCCN received a probability of occurrence of $p = .22$, exactly half that given to the Most Likely Scenario, Business as Usual.

Thus, the group felt that the most desirable course is not the most likely present trajectory.

Appendix E

INDEPENDENT NODES
ECONOMICS SIMULATION MODEL

by

MARC U. PORAT

TABLE OF CONTENTS

INTRODUCTION

The general purpose of the Independent Nodes Economics (INEC) model is to lend insight into the ARPANET divestiture issue and into subsequent network behavior patterns. The INEC model as presented is in its 1973 August 21 stage. Real data have not yet been loaded into the model, e.g., snapshots of the ARPANET topology and statistics.

The model was built on a set of implicit and explicit assumptions. These assumptions are stated here to allow substitution of alternate assumptions which would be more closely representative of the nature of ownership being examined. INEC is a highly generalized model, suitable for various interpretations. In it we assume that each node or a collection of nodes (a sub-net) can be owned by competing entities. Therefore, each gamer on the INEC model represents a sub-net owner. We assume that all sub-nets share a protocol and are interconnected.

ASSUMPTIONS

IMPLICIT ASSUMPTIONS

Assumption 1

The future of the ARPANET is not yet frozen and we are still in a policy R&D stage; decisionmakers involved in the divestiture question will be operating with some mental model of the network's future.

Assumption 2

Network behavior is sufficiently rational and quantifiable to be modeled; and the resulting model will correspond sufficiently to reality as to be useful.

Assumption 3

All players in the game will be seeking to maximize one or more goals; e.g., profits, traffic, security, social welfare, etc.; and all behavior in the model will be guided by these motives.

Assumption 4

An optimal network can develop in a situation wherein each component is optimizing; and that such behavior can occur only under a set of process rules.

Assumption 5

Such rules (or algorithms) can be developed in a modular or parallel fashion; and with repeated experimentation an optimal set of rules can be devised that achieve Assumption 3 (i.e., system optimization without component sub-optimization.)

These five implicit assumptions can be reassembled in terms of explicit assumptions, which in turn can be axiomatized and programmed into the model. These axioms can be altered independently.

EXPLICIT ASSUMPTIONS

Assumption 6

Packet network traffic demand has a measurable growth rate and can be modeled as follows:

(1) Demand = f (computer costs, GNP, previous demand, population)

The growth rate is sensitive to five factors: cost of computation/communication; GNP growth rate; previous demand; population; and a consumer taste variable.

Assumption 7

A network can be described in terms of a finite number of parameters as follows:

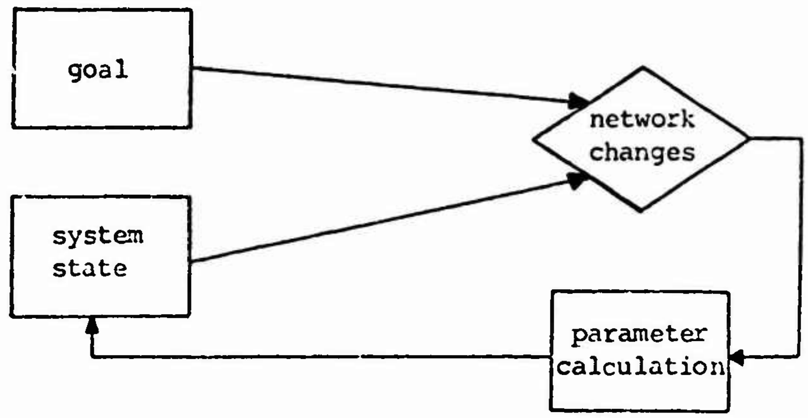
Given	Compute
A network topology	Network performance
A demand matrix	parameters

The performance parameters currently used are:

1. Mean path length.
2. Average capacity.
3. Peak capacity.
4. Average delay.
5. Peak delay.
6. Global reliability.
7. Delta global reliability

Assumption 8

Different topologies can be tested until an optimal network is designed. The fastest convergence on such a design is produced by human/machine interactions, as follows:



Assumption 9

Each configuration can be analyzed on a by-component basis (example: by IMP) in the following manner:

Given

and a traffic matrix

Analyze

Case	IMPS in analysis
1	2, 3, 4
2	1, 3, 4
3	1, 2, 4
4	1, 2, 3
5	All

This iterative method yields each IMP's *contribution* to the network, depending on its location and linkages.

(2) Contribution = f (topology, performance)

Assumption 10

Each sub-net's share of the traffic and revenue pie is computed according to that sub-net's contribution to the network, i.e.,

a sub-net or IMP contributing very little in terms of capacity or reliability, or occasioning delays, will not receive much traffic throughput.

(3) Share of the pie = f (contribution)

Assumption 11

All sub-nets or IMPs charge the same price to all customers, regardless of distance, volume or other function. Therefore, a sub-net's or IMP's revenue is proportional to its share of the pie.

(4) Revenue = f (share of pie, traffic, fixed charges)

Assumption 12

A sub-net's or IMP's "attractiveness" to owners and investors is its profitability, which in turn is based on that sub-net's and the other sub-nets' shares.

(5) Profit = f (maximum share, actual share)

Assumption 13

Sub-net or IMP owners or potential owners who operate under a narrow profit-maximizing criterion will be motivated to change their IMP's location or linkages until profit is being maximized. The model is therefore subject to dynamic growth and change.

IMPLICATIONS

One mode of implementing such a model has been previously described in Paul Goldstein, "The Proposed ARPANET Divestiture: Legal Questions and Economic Issues," CAWP #101, 1973 July 27, and in Marc Porat, "A Decision Tree Addendum to CAWP #101," CAWP #102, 1973 August 8. They have been alternately referred to as the "trade association," "cooperative," or "consortium" methods.

Under the aegis of a consortium of sub-net or IMP owners, a set of orderly procedures are devised. These rules guide both the individual investor and the industry as a whole to achieve optimal growth in the shortest time possible.

One way of avoiding "dead end" or potentially damaging network alterations is to devise an entry algorithm with clear rules applicable to all members.

Assumption 14

The consortium uses the following two entry criteria for *each* discrete change proposed by one of the members of potential members:

1) The proposed network will generate more traffic or revenue than the existing network.
2) The proposed network performance will not degrade the old performance standards.

(6) Entry = f (network revenue, traffic, performance)

Assumption 15

The consortium can change its own rules of entry according to a charter.

Assumption 16

The ARPANET divestiture might be useful as leverage in developing the consortium charter.

Note: the model is to be run in BASIC (Interactive) time-sharing mode. The model resides in the Interactive Application, Inc.[1] *system and can be accessed by typing "GET-INEC."*

The INEC model is written for a maximum 10-node network. It occupies almost 100,000 words in BASIC,[2] *and can therefore not be expanded to a 20- or 40-node network. If such a network is desired, the model can readily be translated into another language to run on a larger system.*

[1] Cabledata Associates, Inc., maintains an account at Interactive Applications, Inc. Contact Marc Porat for arrangements.

[2] Maximum size = 100,000 words.

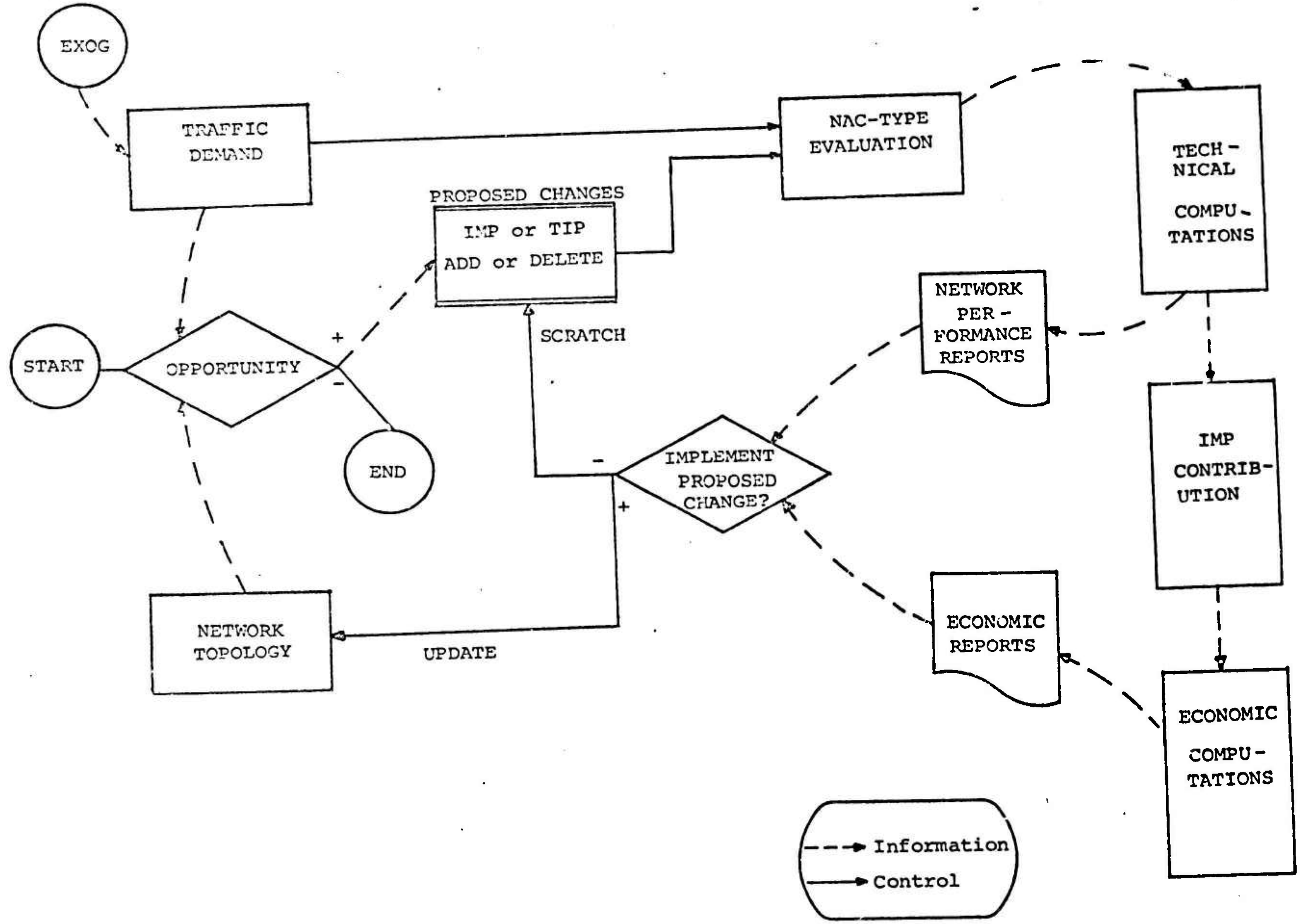


Figure 1. Independent Nodes Economics (INEC) Simulation and Gaming Model (1973 August 6).

```
15  REM *******************************************************
30  REM              INDEPENDENT NODES ECONOMICS (INEC)
45  REM                    TABLEDATA  ASSOCIATES
60  REM                     VERSION  8-5-77
90  DIM C$[10]
105  PRINT "DO YOU NEED A USER'S MANUAL(YES,NO)";
120  INPUT C$
135  IF C$="NO" THEN 180
150  IF C$#"YES" THEN 105
165  CHAIN "INTRO"
180  PRINT "DO YOU NEED A DICTIONARY";
195  INPUT C$
210  IF C$="NO" THEN 240
225  CHAIN "DICT"
240  REM ------------------  MATRICES AND DIMENSIONS  -------------
255  REM                                    EXISTING      PROPOSED
270  REM                                     (OLD)         (NEW)
300  REM CONTRIBUTION                          B             C
315  REM PIE DIVISION (SHARE)                  D             E
330  REM PERFORMANCE RATIO                     F
345  REM MONTHLY GROWTH RATES                  G
360  REM REVENUES TO IMPS                      H             I
375  REM NETWORK LINKAGES                      L             M
390  REM MODEL EVALUATION                      N
405  REM IMPS INVENTORY                        O             P
420  REM BASIC TRAFFIC DEMAND                  S             T
435  REM PROFIT AND LOSS TO IMPS               U             V
450  REM INVESTMENT THRESHOLD                  W             X
465  REM CONVERSATIONAL INPUT                  B$,C$,D$
480  REM CHARACTER STRING DATA                 A$,R$
495  REM ------------  CONSTANTS  ---------------
510  REM # IMPS                      N1        N2
525  REM DATA INPUT                  A,B,D
540  REM TARRIF                      T
555  REM TOTAL NETWORK TRAFFIC  T1        T2
570  REM TOTAL NETWORK REVENUE  R1        R2
585  REM ---------------  DIMENSION DECLARATION  ----------
600  DIM B[10],C[10]
615  DIM D[10],E[10],H[10]
630  DIM I[10],O[10],R[10]
645  DIM U[10],V[10]
660  DIM N[11,7]
675  DIM D[7],F[7],F[7]
690  DIM L[10,10],M[10,10]
705  DIM S[10,10],T[10,10]
720  DIM A[10,10]
735  DIM G[120,2]
750  DIM A$[19],B$[1]
765  DIM R$[50]
780  REM  INITIALIZING THE MODEL
795  REM  K IS THE SIMULATION CLOCK, KEPT BY MONTHS
810  REM  TO CHANGE "TIME", INPUT "T" TO THE COMMAND MODE.
825  C1=1
840  FOR K=C1 TO 120
855  IF D$#"YES" THEN 870
856  C1=1
860  GOSUB 8175
865  GOTO 960
```

```
870  GOSUB 7890
885  PRINT "IS THIS A NEW (0) OR CONTINUATION (1) RUN";
900  INPUT C
915  IF C=0 THEN 8295
930  IF C=1 THEN 3785
945  GOTO 885
960  REM --------------  USER CONVERSATIONAL INPUTS  --------
975  A=B=0
990  PRINT "COMMAND";
1005  INPUT B$
1020  IF B$="E" THEN 2580
1035  IF B$="R" THEN 1185
1050  IF B$="I" THEN 1230
1065  IF B$="L" THEN 1305
1080  IF B$="S" THEN 7440
1095  IF B$="N" THEN 7140
1110  IF B$="H" THEN 1170
1125  IF B$="T" THEN 1575
1140  PRINT "COMMAND NOT RECOGNIZED"
1155  GOTO 960
1170  CHAIN "INTRO"
1185  PRINT "REPORT #";
1200  INPUT A
1215  GOTO 1380
1230  PRINT "IMP ADD/DELETE";
1245  INPUT B$
1260  PRINT "IMP #";
1275  INPUT A
1290  GOTO 1665
1305  PRINT "LINK ADD/DELETE";
1320  INPUT B$
1335  PRINT "LINK #'S",
1350  INPUT A,B
1365  GOTO 1950
1380  REM  REPORT ACCESS BY NUMBER
1395  IF A=1 THEN 5190
1410  IF A=2 THEN 5385
1425  IF A=3 THEN 5445
1440  IF A=4 THEN 5550
1455  IF A=5 THEN 5655
1470  IF A=6 THEN 5805
1485  IF A=7 THEN 5955
1500  IF A=8 THEN 6235
1515  IF A=9 THEN 6495
1530  IF A=10 THEN 6675
1545  PRINT "REPORT";A;"NOT FOUND"
1560  GOTO 960
1575  PRINT "INPUT TIME (MAX 1978.1)"
1590  INPUT C1
1605  C1=(C1-1968)*10
1620  K=A
1635  GOSUB 8175
1650  GOTO 960
1665  REM --------------  BLACK BOX  ---------------
1680  REM DELETE IMPS
1695  IF B$="A" THEN 1845
1710  IF B$#"D" THEN 1140
1724  IF A>10 THEN 1800
1725  IF P[A]=0 THEN 1800
1740  N2=N2-1
```

```
1755  P[A]=0
1770  PRINT "IMP #";A;"DELETED"
1785  GOTO 2460
1800  PRINT "IMP #";A;"NOT THERE TO DELETE"
1815  GOTO 960
1830  REM  ADD IMPS
1845  IF P[A]=A THEN 1920
1860  N3=N3+1
1875  P[A]=A
1890  PRINT "IMP #";A;"ADDED"
1905  GOTO 2580
1920  PRINT "IMP #";A;"ALREADY THERE"
1935  GOTO 960
1950  REM  LINKS
1965  REM  DELETE LINKS
1980  IF A <> B THEN 2025
1995  PRINT "ERROR, PLEASE RETYPE"
2010  GOTO 960
2025  IF B$="A" THEN 2250
2040  IF B$#"D" THEN 1140
2042  IF A>10 THEN 2085
2044  IF B>10 THEN 2130
2055  IF M[A,B]=0 THEN 2220
2070  IF P[A]#0 THEN 2160
2085  PRINT "IMP";A;"DOES NOT EXIST; IMPOSSIBLE TO DELETE LINK"
2100  GOTO 960
2115  IF P[B]#0 THEN 2160
2130  PRINT "IMP";B;"DOES NOT EXIST; IMPOSSIBLE TO DELETE LINK"
2145  GOTO 960
2160  M[A,B]=0
2175  M[B,A]=0
2190  PRINT "LINKS";A;B;"DELETED"
2205  GOTO 2580
2220  PRINT "LINKS";A;B;"NOT THERE TO DELETE"
2235  GOTO 960
2250  REM  LINK ADDITION
2252  IF A>10 THEN 2280
2254  IF B>10 THEN 2325
2265  IF P[A] <> 0 THEN 2310
2280  PRINT "IMP";A;"DOES NOT EXIST; LINK ADD IMPOSSIBLE"
2295  GOTO 960
2310  IF P[B] <> 0 THEN 2355
2325  PRINT "IMP";B;"DOES NOT EXIST; LINK ADD IMPOSSIBLE"
2340  GOTO 960
2355  IF M[A,B]=1 THEN 2430
2370  M[A,B]=1
2385  M[B,A]=1
2400  PRINT "LINKS"A;B;"ADDED"
2415  GOTO 2580
2430  PRINT "LINKS";A;B;"ALREADY THERE"
2445  GOTO 960
2460  REM  IMP DROP CAUSING LINK DROPS (AUTOMATIC)
2475  FOR I=1 TO 10
2490  IF I=A THEN 2565
2505  IF M[I,A]=0 THEN 2565
2520  M[I,A]=0
2535  M[A,I]=0
2550  PRINT "LINK";I;A;"DROPPED"
2565  NEXT I
2580  PRINT "NETWORK EVALUATION?"
```

```
2595  INPUT C$
2610  IF C$="NO" THEN 260
2625  IF C$#"YES" THEN 1140
2640  REM  MAKING A HALF-FILE
2655  PRINT "PREPARE TO MAKE A FILE WHEN MESSAGE ENDS:"
2670  PRINT "    (1)  TURN ON PUNCH OF CASETTE READ"
2685  PRINT "    (2)  PRESS 'HERE IS' TWICE"
2700  PRINT "    (3)  PAUSE FOR 15 SECONDS"
2715  REM PROGRAM A PAUSE
2730  ENTER 15,A,B
2745  G$=","
2760  FOR I=1 TO 10
2775  PRINT B[I];G$;D[I];G$;H[I];G$;O[I];G$;R[I];G$;U[I]
2790  NEXT I
2805  PRINT C[1];G$;C[2];G$;C[3];G$;C[4];G$;C[5];G$;C[6];G$;C[7]
2820  PRINT N1;G$;N2;G$;P1;G$;T1;G$;K
2835  FOR I=1 TO 10
2850  FOR J=1 TO 10
2865  IF L[I,J]=0 THEN 2895
2880  IF L[I,J]=1 THEN 2925
2895  PRINT "0";
2910  GOTO 2940
2925  PRINT "1";
2940  IF I*J#50 THEN 2985
2955  IF I=10 THEN 2985
2970  PRINT
2985  NEXT J
3000  NEXT I
3015  PRINT
3030  FOR I=1 TO 10
3045  FOR J=1 TO 10
3060  IF M[I,J]=0 THEN 3090
3075  IF M[I,J]=1 THEN 3120
3090  PRINT "0";
3105  GOTO 3135
3120  PRINT "1";
3135  IF I*J#50 THEN 3180
3150  IF I=10 THEN 3180
3165  PRINT
3180  NEXT J
3195  NEXT I
3210  PRINT
3240  REM  PROGRAMMED PAUSE FOR SWITCHING TO THE NETWORK EVALUATION
                                                                TAPE
3255  ENTER 180,A,B
3260  IF A=99 THEN 7960
3270  PRINT "PREPARE TO MAKE THE NETWORK EVALUATION DATA"
3285  PRINT "NOW, TURN ON PUNCH (15 SEC PAUSE)"
3300  ENTER 15,A,B
3315  FOR I=1 TO 10
3330  FOR J=1 TO 10
3345  IF M[I,J]=0 THEN 3375
3360  IF M[I,J]=1 THEN 3405
3375  PRINT "0";
3390  GOTO 3420
3405  PRINT "1";
3420  IF I*J#50 THEN 3465
3435  IF I=10 THEN 3465
3450  PRINT
3465  NEXT J
3480  NEXT I
```

```
3495  PRINT
3510  FOR I=1 TO 10
3525  PRINT T[1,I];G$;T[2,I];G$;T[3,I];G$;T[4,I];G$;T[5,I]
3540  PRINT T[6,I];G$;T[7,I];G$;T[8,I];G$;T[9,I];G$;T[10,I]
3555  NEXT I
3570  PRINT LIN(3)
3585  ENTER 60,A,B
3600  PRINT "END OF SESSION. BYE."
3615  STOP
3630  REM  ********************************************************
3645  REM  PROGRAM STOPS AT THIS POINT WHILE PROPOSED CHANGES IN THE
3660  REM  NETWORK TOPOLOGY GO THROUGH A NAC-TYPE EVALUATION.
3675  REM  ALL RELEVENT DATA IS STORED ON A TAPE CASETTE, PAPER TAPE,
3690  REM  OR SOME OTHER CONVENIENT MEDIUM (NO, NOT SORTICAL).
3705  REM  ********************************************************
3720  REM  PERFORMANCE OUTPUTS FROM NAC IN N(11,7)
3735  REM  N(I,1)= MEAN PATH LENGTH
3750  REM  N(I,2)=AVERAGE CAPACITY
3765  REM  N(I,3)=PEAK CAPACITY
3780  REM  N(I,4)=AVERAGE DELAY
3795  REM  N(I,5)=PEAK DELAY
3810  REM  N(I,6)=AVERAGE RELIABILITY
3825  REM  N(I,7)=MINIMUM RELIABILITY
3840  REM  I=1 TO 11; EACH I CONTAINS THE ARRAY OF DATA FOR THE
3855  REM  ITH. IMP'S CONTRIBUTION TO THE NETWORK.  SEE CONTRIBUTION
3870  REM  EQUATION BELOW.
3885  REM  CONTINUATION RUN INTIALIZING
3900  PRINT "LOAD OLD CASETTE OR PAPER TAPE FOR CONTINUATION RUN"
3915  FOR I=1 TO 10
3930  INPUT B[I],D[I],H[I],O[I],P[I],U[I]
3945  NEXT I
3960  INPUT O[1],O[2],O[3],O[4],O[5],O[6],O[7]
3975  INPUT N1,N2,R1,T1,K
3990  INPUT R$
4005  S=0
4020  FOR I=1 TO 10
4035  IF I#6 THEN 4065
4050  INPUT R$
4065  FOR J=1 TO 10
4080  S=S+1
4095  IF R$[S,S]="0" THEN 4140
4110  L[I,J]=1
4125  GOTO 4155
4140  L[I,J]=0
4155  NEXT J
4170  NEXT I
4185  INPUT R$
4200  S=0
4215  FOR I=1 TO 10
4230  IF I#6 THEN 4260
4245  INPUT R$
4260  FOR J=1 TO 10
4275  S=S+1
4290  IF R$[S,S]="0" THEN 4335
4305  M[I,J]=1
4320  GOTO 4350
4335  M[I,J]=0
4350  NEXT J
4365  NEXT I
```

```
4380  PRINT "INITIALIZING INPUT O.K"
4395  PRINT "PREPARE TO INPUT THE NUMBER EVALUATION DATA"
4400  ENTER 15,A,B
4410  FOR I=1 TO 11
4425  INPUT N[I,1],N[I,2],N[I,3],N[I,4],N[I,5],N[I,6],N[I,7]
4440  NEXT I
4455  PRINT "NAC INPUT O.K"
4470  REM  CONTRIBUTION EQUATION C(I)
4485  REM W'S AND K'S ARE ARBITRARILY CHOSEN WEIGHTS
4500  K2=K3=4
4515  K6=K7=4
4530  K4=K5=1
4545  W1=1
4560  W2=.3
4575  W3=.7
4590  FOR I=1 TO 10
4605  A1=W1*(1/N[I,1])
4620  A2=W2*(K2*N[I,2])*(K4*N[I,4])*(K6*N[I,6])
4635  A3=W3*(K3*N[I,3])*(K5*N[I,5])*(K7*N[I,7])
4650  C[I]=A1*A2*A3
4665  NEXT I
4680  REM  INITIALIZING THE CONSTANTS
4695  R2=T2=Z=0
4710  REM  ---------  ECONOMIC REPORT COMPUTATIONS  -------------
4725  REM  --  PIE DIVISION : E(I)  --
4740  FOR I=1 TO 10
4755  Z=Z+C[I]
4770  NEXT I
4785  FOR I=1 TO 10
4800  E[I]=C[I]/Z
4815  NEXT I
4830  REM  --  TOTAL TRAFFIC T2  --
4845  GOSUB 8175
4860  FOR I=1 TO 10
4875  FOR J=1 TO 10
4890  IF M[I,J]=0 THEN 4920
4905  T2=T2+T[I,J]
4920  NEXT J
4935  NEXT I
4950  REM  --  IMP REVENUE : I(J)  --
4965  FOR J=1 TO 10
4980  I[J]=E[J]*T2*T
4995  NEXT J
5010  REM  --  TOTAL REVENUE R2  --
5025  FOR J=1 TO 10
5040  R2=R2+I[J]
5055  NEXT J
5070  REM  --  IMP PROFIT & LOSS  :  V(I)  --
5085  FOR I=1 TO 10
5100  V[I]=(E[I]-1/N2)*T2*T
5115  NEXT I
5130  GOTO 6915
5145  REM  --------------- REPORT GENERATION  ----------------
5160  REM  REPORT #1
5175  PRINT LIN(2)
5190  PRINT "----------- TRAFFIC DEMAND 1968.1 ----------"
5205  PRINT "                PACKET THROUGHPUT IN '000S
5220  PRINT "   1      2      3      4      5      6      7      8      9
5235  PRINT
```

```
5250  IF A=2 THEN 5400
5265  MAT PRINT USING 5280;L
5280  IMAGE 10(5D.2D)
5295  PRINT LIN(2)
5310  GOTO 960
5325  REM  REPORT 2
5340  PRINT LIN(2)
5355  PRINT "---------- TRAFFIC DEMAND";1968+(C1/10);"----------"
5370  GOTO 5205
5385  PRINT LIN(2)
5400  MAT PRINT USING 5280;T
5415  PRINT LIN(2)
5430  GOTO 960
5445  REM  --  REPORT 3  --
5460  PRINT LIN(2)
5475  PRINT "---------- OLD NETWORK TOPOLOGY ----------"
5490  PRINT LIN(2)
5505  MAT PRINT L;
5520  PRINT LIN(2)
5535  GOTO 960
5550  REM  --  REPORT 4  --
5565  PRINT LIN(2)
5580  PRINT "---------- NEW NETWORK TOPOLOGY ----------"
5595  PRINT LIN(2)
5610  MAT PRINT N;
5625  PRINT LIN(2)
5640  GOTO 960
5655  REM --  REPORT 5  --
5670  PRINT LIN(2)
5685  PRINT "---------- OLD IMPS INVENTORY ----------"
5700  PRINT LIN(2)
5715  FOR I=1 TO 10
5730  IF O[I]=0 THEN 5760
5745  PRINT O[I];
5760  NEXT I
5775  PRINT LIN(2)
5790  GOTO 960
5805  REM --  REPORT 6  --
5820  PRINT LIN(2)
5835  PRINT "---------- NEW IMPS INVENTORY ----------"
5850  PRINT LIN(2)
5865  FOR I=1 TO 10
5880  IF P[I]=0 THEN 5910
5895  PRINT P[I];
5910  NEXT I
5925  PRINT LIN(2)
5940  GOTO 960
5955  REM  --  REPORT 7  --
5970  GOSUB 7365
5985  RESTORE 6075
6000  PRINT LIN(2)
6015  PRINT "---------- NETWORK PERFORMANCE OUTPUTS ----------"
6030  PRINT LIN(2)
6045  PRINT "                              OLD       NEW       DIFF      PC
6060  PRINT
6075  DATA "MEAN PATH LENGTH"
6090  DATA "AVERAGE CAPACITY"
6105  DATA "PEAK CAPACITY"
6120  DATA "AVERAGE DELAY"
6135  DATA "PEAK DELAY"
```

```
6150  DATA "AVERAGE RELIABILITY"
6165  DATA "MINIMUM RELIABILITY"
6180  FOR I=1 TO 7
6195  READ A$
6210  PRINT  USING 6225;A$,O[I],R[I],R[I]-O[I],R[I]/O[I]
6225  IMAGE 19A,5X,4(2D.3D,2X)
6240  NEXT I
6255  PRINT LIN(2)
6270  GOTO 960
6285  REM  --  REPORT 8  --
6300  PRINT LIN(2)
6315  PRINT "---------- OLD ECONOMIC REPORT ----------"
6330  PRINT LIN(2)
6345  PRINT "IMP #";TAB(10);"CONTRIBUTION";TAB(25);
6360  PRINT "MARKET SHARE";TAB(41);"REVENUE";TAB(53);"PROFIT (LOSS)"
6375  PRINT
6390  IF A=9 THEN 6585
6405  FOR I=1 TO 10
6420  IF O[I]=0 THEN 6450
6435  PRINT I;TAB(12);B[I];TAB(26);D[I];TAB(40);H[I];TAB(52);U[I]
6450  NEXT I
6465  PRINT LIN(2)
6480  GOTO 960
6495  REM  --  REPORT 9  --
6510  GOSUB 7365
6525  PRINT LIN(2)
6540  PRINT "---------- NEW ECONOMIC REPORT ----------"
6555  PRINT LIN(2)
6570  GOTO 6345
6585  FOR J=1 TO 10
6600  IF R[J]=0 THEN 6630
6615  PRINT J;TAB(12);C[J];TAB(26);E[J];TAB(40);I[J];TAB(52);V[J]
6630  NEXT J
6645  PRINT LIN(2)
6660  GOTO 960
6675  REM  --  REPORT 10  --
6690  GOSUB 7365
6705  PRINT LIN(2)
6720  PRINT "---------- NETWORK SUMMARY ----------"
6735  PRINT LIN(2)
6750  PRINT TAB(12);"TOTAL";TAB(26);"AVERAGE";
6765  PRINT TAB(38);"TOTAL";TAB(50);"AVERAGE"
6780  PRINT TAB(11);"NETWORK";TAB(26);"IMP";
6795  PRINT TAB(37);"NETWORK";TAB(53);"IMP"
6810  PRINT TAB(11);"TRAFFIC";TAB(26);"TRAFFIC";
6825  PRINT TAB(37);"REVENUE";TAB(50);"REVENUE"
6840  PRINT "OLD";TAB(11);T1;TAB(26);T1/N1;TAB(37);R1;TAB(50);R1/N1
6855  PRINT "NEW";TAB(11);T2;TAB(26);T2/N2;TAB(37);R2;TAB(50);R2/N2
6870  PRINT "RATIO";TAB(11);T2/T1
6885  PRINT LIN(2)
6900  GOTO 960
6915  REM  --------------  SIMULATION RESET  --------------
6930  Z=0
6945  REM PROPOSAL ACCEPTANCE
6960  FOR I=1 TO 7
6975  F[I]=N[11,I]
6990  NEXT I
7005  FOR I=1 TO 7
7020  F[I]=F[I]/O[I]
7035  Z=Z+F[I]
```

```
7050  NEXT I
7065  IF Z(I)>1.2 THEN 7110
7080  PRINT "RECCOMMEND REJECT CHANGE: Z=";Z
7095  GOTO 960
7110  PRINT "RECCOMMEND ACCEPT CHANGE: Z=";Z
7125  GOTO 960
7140  REM  PROPOSED CHANGE ABORTED
7155  GOSUB 7365
7170  MAT C=ZER
7185  MAT E=ZER
7200  MAT I=ZER
7215  MAT M=ZER
7230  MAT P=ZER
7245  MAT R=ZER
7260  MAT T=ZER
7275  MAT V=ZER
7290  N2=0
7305  R2=0
7320  T2=0
7335  PRINT "PROPOSED CHANGE ABORTED"
7350  GOTO 7650
7365  REM SUBROUTINE: CHECKS IF EVALUATION IS COMPLETED
7380  IF C=1 THEN 7425
7395  PRINT "SORRY: YOUR PROPOSED CHANGES HAVE NOT YET BEEN EVALUATED"
7410  GOTO 960
7425  RETURN
7440  REM PROPOSED CHANGE IMPLEMENTED
7455  GOSUB 7365
7470  MAT B=C
7485  MAT D=E
7500  MAT H=I
7515  MAT L=M
7530  MAT O=P
7545  MAT Q=R
7560  MAT S=T
7575  MAT U=V
7590  N1=N2
7605  R1=R2
7620  T1=T2
7635  PRINT "PROPOSED CHANGE IMPLEMENTED"
7650  PRINT
7665  PRINT "CONTINUE?"
7680  INPUT D$
7695  IF D$="NO" THEN 7770
7710  IF D$="YES" THEN 7755
7725  GOTO 7665
7755  NEXT K
7770  PRINT "SAVE FILE?"
7785  INPUT C$
7800  IF C$="NO" THEN 7860
7815  PRINT LIN(2)
7830  A=99
7845  GOTO 2640
7860  PRINT "END OF SESSION. BYE."
7875  STOP
7890  REM  INTIALIZING THE RESIDENT VARIABLES
7905  REM  MAT G,I,J TARRIF T
7920  REM  MAT S STORES THE BASIC TRAFFIC MATRIX (1969)
7921  RESTORE 7935
7935  DATA 33,202,96,14,52,249,414,3,[illegible]9,53
```

```
7950  DATA 205,17,63,1054,34,1,1,2,1,12
7965  DATA 85,54,170,12,20,23,68,44,277,16
7980  DATA 16,1154,24,5,.7,3,5,2,3,2
7995  DATA 33,29,24,1,7,59,7,11,39,60
8010  DATA 250,.5,34,9,56,.75,.7,81,0,5
8025  DATA 437,1,.01,9,16,.7,101,7,35,2
8040  DATA 3,2,39,2,3,64,6,321,4,5
8055  DATA 92,.6,255,8,43,0,35,7,7,2
8070  DATA 17,5,48,.6,2,12,.7,42,3,2
8085  MAT  READ S[10,10]
8100  REM  G IS THE MONTHLY GROWTH RATE OF DATA TRAFFIC DEMAND
8115  G=1.01
8130  REM  TARRIF STORED IN T
8145  T=20
8160  RETURN
8175  REM SUBROUTINE: BRINGING THE MODEL UP TO SPEED
8190  MAT T=S
8205  FOR H=1 TO C1
8220  MAT T=(G)*T
8235  NEXT H
8250  PRINT "SIMULATION TIME:";1969+(C1/10)
8265  PRINT "READY"
8280  RETURN
8295  REM INITIALIZING A NEW (0) RUN
8310  REM  -- B,D,H,J,U,Q,O  --
8325  FOR I=1 TO 10
8340  B[I]=100
8355  D[I]=.1
8370  H[I]=1
8385  U[I]=1
8400  Q[I]=I
8415  NEXT I
8430  REM  INIT O: PERFORMANCE DATA
8445  FOR I=1 TO 7
8460  O[I]=1
8475  NEXT I
8490  REM  INIT MAT L: LINKAGES
8505  MAT L=IDN
8520  REM  INIT CONSTANTS
8535  A=B=D=0
8550  F=1
8565  P1=T1=1
8580  N1=N2=10
8595  REM INITIALIZING THE BLACK BOX
8610  MAT M=L
8625  MAT R=0
8640  C1=2
8655  GOSUB 8175
8670  GOTO 960
8685  END
```

INEC DICTIONARY

THE USER WILL FREQUENTLY BE PROMPTED FOR INPUT TO CONTROL THE MODEL OPERATION. WHEN THE MODEL IS IN THE COMMAND MODE, ANY OF THE FOLLOWING INPUTS MAY BE USED: (TYPING THE FIRST LETTER ONLY IS SUFFICIENT)

A=A(DD)	TO ADD AN IMP OR A LINK.
D=D(ELETE)	TO DELETE AN IMP OR A LINK.
E=E(VALUATE)	TO SEND THE PROPOSED CHANGES TO THE NETWORK EVALUATION MODEL.
G=G(O)	TO APPROVE AND IMPLEMENT A PROPOSED CHANGE FOLLOWING A MODEL EVALUATION.
I=I(MP)	TO INITIATE AN IMP OPERATION SEQUENCE.
L=L(INK)	TO INITIATE A LINK OPERATION SEQUENCE.
N=N(OGO)	TO REJECT AND ABORT A PROPOSED CHANGE FOLLOWING A MODEL EVALUATION.
R=R(EPORT)	TO CALL UP ONE OF THE TEN REPORTS.

REPORTS	OLD	NEW	BOTH
TRAFFIC DEMAND	1	2	
NETWORK TOPOLOGY	3	4	
IMPS INVENTORY	5	6	
NETWORK PERFORMANCE			7
ECONOMIC REPORTS	8	9	
NETWORK SUMMARY			10

T=T(IME)	TO BRING THE TRAFFIC DEMAND MATRIX UP TO ANY USER SPECIFIED TIME

THE USER WILL ALSO BE PROMPTED FOR 'YES' AND 'NO' ANSWERS, AND FOR A '0' OR '1' ANSWER. IF AN INPUT ERROR IS MADE, THE USER WILL USUALLY BE PUT BACK INTO THE COMMAND MODE FOLLOWING AN ERROR MESSAGE.

SAMPLE INEC RUN

The following is the output of an INEC session. The data shown is for demonstration purposes only. The machine prompts the user with a statement followed by a '?'. The user responds with the appropriate command.

```
GET-INEC
RUN
INEC

DØ YUU NEED A USER'S MANUAL (YES, NØ)?
?NØ
DØ YØU NEED A DICTIØNARY?
?NØ
IS THIS A NEW ('0') ØR CØNTINUATIØN ('1') RUN ?
?0
SIMULATIØN TIME: 1968.2
READY
CØMMAND?R
REPØRT #?1
---------- TRAFFIC DEMAND 1968.1 ----------
               PACKET THROUGHPUT IN '000S
```

1	2	3	4	5	6	7	8	9	10
33	202	96	14	52	249	414	3	89	53
205	19	63	1054	34	1	1	2	1	12
85	54	170	22	30	23	68	44	238	16
10	1194	24	5	1	9	5	2	8	2
33	29	24	1	7	59	7	11	39	60
250	1	34	9	66	475	1	81	0	5
437	1	81	9	16	1	101	9	35	2
3	2	39	2	8	64	6	321	4	5
92	1	255	8	43	0	35	7	7	2
17	5	48	1	2	12	1	42	3	2

```
CØMMAND?R
REPØRT #?2

---------- TRAFFIC DEMAND 1968.2   ----------
               PACKET THRØUGHPUT IN '000S
```

1	2	3	4	5	6	7	8	9	10
34	206	98	14	53	254	422	3	91	54
209	19	64	1075	35	1	1	2	1	12
87	55	173	22	31	23	69	45	243	16
10	1218	24	5	1	9	5	2	8	2
34	30	24	1	7	60	7	11	40	61
255	1	35	9	67	485	1	83	0	5
446	1	83	9	16	1	103	9	36	2
3	2	40	2	8	65	6	327	4	5
94	1	260	8	44	0	36	7	7	2
17	5	49	1	2	12	1	43	3	2

```
CØMMAND?R
REPØRT #73
```

A '1' represents a link; a '0' represents no link. The topology was initialized as the identity matrix; i.e., no links.

---------- ØLD NETWØRK TØPØLØGY ----------

1	0	0	0	0	0	0	0	0	0
0	1	0	0	0	0	0	0	0	0
0	0	1	0	0	0	0	0	0	0
0	0	0	1	0	0	0	0	0	0
0	0	0	0	1	0	0	0	0	0
0	0	0	0	0	1	0	0	0	0
0	0	0	0	0	0	1	0	0	0
0	0	0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	0	1	0
0	0	0	0	0	0	0	0	0	1

```
CØMMAND?R
REPØRT #77
SØRRY: YØUR PRØPØSED CHANGES HAVE NØT YET BEEN EVALUATED
CØMMAND?R
REPØRT #78
```

User asked for network performance outputs which are as yet unavailable.

---------- ØLD ECØNØMIC REPØRT ----------

IMP #	CØNTRIBUTIØN	MARKET SHARE	REVENUE	PRØFIT (LØSS)
1	100	.1	1	1
2	100	.1	1	1
3	100	.1	1	1
4	100	.1	1	1
5	100	.1	1	1
6	100	.1	1	1
7	100	.1	1	1
8	100	.1	1	1
9	100	.1	1	1
10	100	.1	1	1

```
COMMAND?R
REPORT #?9
SORRY: YOUR PROPOSED CHANGES HAVE NOT YET BEEN EVALUATED
COMMAND?R
REPORT #?10
SORRY: YOUR PROPOSED CHANGES HAVE NOT YET BEEN EVALUATED
COMMAND?I
IMP ADD/DELETE?A
IMP #?2
IMP # 2    ALREADY THERE
COMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?1,2
LINKS 1      2     ADDED
NETWORK EVALUATION?
?NO
COMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?1,2
LINKS 1      2  -  ALREADY THERE
COMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?2,3
LINKS 2      3     ADDED
NETWORK EVALUATION?
?NO
COMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?3,4
LINKS 3      4     ADDED
NETWORK EVALUATION?
?NO
COMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?4,5
LINKS 4      5     ADDED
NETWORK EVALUATION?
?NO
COMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?5,6
LINKS 5      6     ADDED
NETWORK EVALUATION?
?NO
COMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?6,7
LINKS 6      7     ADDED
NETWORK EVALUATION?
?NO
COMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?7,8
LINKS 7      8     ADDED
```

The user is adding links to the network. INEC accepts new links for evaluation...

```
COMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?9,10
LINKS 9      10   ADDED
NETWØRK EVALUATIØN?
?NØ
CØMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?1,5
LINKS 1      5    ADDED
NETWØRK EVALUATIØN?
?NØ
CØMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?5,10
LINKS 5      10   ADDED
NETWØRK EVALUATIØN?
?NØ
CØMMAND?L
LINK ADD/DELETE?A
LINK #'S, E.G. 2,4?1,10
LINKS 1      10   ADDED
NETWØRK EVALUATIØN?
?NØ
CØMMAND?R
REPØRT #?4
```

...and this is the resulting topology.

```
---------- NEW NETWØRK TØPØLØGY ----------

1  1  0  0  1  0  0  0  0  1
1  1  1  0  0  0  0  0  0  0
0  1  1  1  0  0  0  0  0  0
0  0  1  1  1  0  0  0  0  0
1  0  0  1  1  1  0  0  0  1
0  0  0  0  1  1  1  0  0  0
0  0  0  0  0  1  1  1  0  0
0  0  0  0  0  0  1  1  1  0
0  0  0  0  0  0  0  1  1  1
1  0  0  0  1  0  0  0  1  1
```

At this point the user is ready for an evaluation. All relevant data are dumped. A more recent version of INEC accepts output on a Texas Instruments Model 733 tape cassette.

```
COMMAND?E
NETWORK EVALUATION?
?YES
PREPARE TO MAKE THE HALF-FILE; THE FIRST OUTPUT WILL BE
USED TO RELOAD THE MODEL ON A CONTINUATION RUN.
NOW TURN ON PUNCH (15 SEC PAUSE)
 100  , .1          , 1   , 1   , 1   , 1
 100  , .1          , 1   , 2   , 2   , 1
 100  , .1          , 1   , 3   , 3   , 1
 100  , .1          , 1   , 4   , 4   , 1
 100  , .1          , 1   , 5   , 5   , 1
 100  , .1          , 1   , 6   , 6   , 1
 100  , .1          , 1   , 7   , 7   , 1
 100  , .1          , 1   , 8   , 8   , 1
 100  , .1          , 1   , 9   , 9   , 1
 100  , .1          , 1   , 10  , 10  , 1
 .0001      , .0001      , .0001      , .0001      , .0001      ,
 .0001      , .0001
 10   , 10   , 1    , 1    , 1
100000000001000000000010000000000100000000001000000
000001000000000001000000000001000000000001000000000001
110010000111100000000111000000001110000010011100001
000011100000000111000000001110000000011110001000011
PREPARE TO MAKE THE NETWORK EVALUATION DATA
NOW, TURN ON PUNCH (15 SEC PAUSE)
110010000111100000000111000000001110000010011100001
000011100000000111000000001110000000011110001000011
 33.6633    , 209.12     , 86.7085    , 10.201     , 33.6633
 255.025    , 445.784    , 3.0603     , 93.8492    , 17.3417
 206.06     , 19.3819    , 55.0854    , 1218.      , 29.5829
 .51005     , 1.0201     , 2.0402     , .61206     , 5.1005
 97.9296    , 64.2663    , 173.417    , 24.4824    , 24.4824
 34.6834    , 82.6281    , 39.7839    , 260.125    , 48.9648
 14.2814    , 1075.19    , 22.4422    , 5.1005     , 1.0201
 9.1809     , 9.1809     , 2.0402     , 8.1608     , .61206
 53.0452    , 34.6834    , 30.603     , .71407     , 7.1407
 67.3266    , 16.3216    , 8.1608     , 43.8643    , 2.0402
 254.005    , 1.0201     , 23.4623    , 9.1809     , 60.1859
 484.547    , .71407     , 65.2864    , 0     , 12.2412
 422.321    , 1.0201     , 69.3668    , 5.1005     , 7.1407
 .71407     , 103.03     , 6.1206     , 35.7035    , .71407
 3.0603     , 2.0402     , 44.8844    , 2.0402     , 11.2211
 82.6231    , 9.1809     , 327.452    , 7.1407     , 42.8442
 90.7889    , 1.0201     , 242.784    , 8.1608     , 39.7839
 0     , 35.7035    , 4.0804     , 7.1407     , 3.0603
 54.0653    , 12.2412    , 16.3216    , 2.0402     , 61.206
 5.1005     , 2.0402     , 5.1005     , 2.0402     , 2.0402
```

The session is over until the network evaluation parameters are returned.

```
END OF SESSION. BYE.

DONE
```

```
.GET-INEC
RUN
INEC
```

The user is ready for a continuation run. The old system state statistics are fed in and the model is initialized.

```
DØ YØU NEED A USER'S MANUAL (YES, NO)?
?NO
DØ YØU NEED A DICTIØNARY?
?NØ
IS THIS A NEW ('O') ØR CONTINUATIØN ('1') RUN ?
?1
LØAD ØLD CASETTE ØR PAPER TAPE FØR CONTINUATIØN RUN
? 100   , .1          , 1   , 1    , 1    , 1
?
  100   , .1          , 1   , 2    , 2    , 1
?
  100   , .1          , 1   , 3    , 3    , 1
?
  100   , .1          , 1   , 4    , 4    , 1
?
  100   , .1          , 1   , 5    , 5    , 1
?
  100   , .1          , 1   , 6    , 6    , 1
?
  100   , .1          , 1   , 7    , 7    , 1
?
  100   , .1          , 1   , 8    , 8    , 1
?
  100   , .1          , 1   , 9    , 9    , 1
?
  100   , .1          , 1   , 10   , 10   , 1
?
  .0001       , .0001       , .0001       , .0001       , .0001       ,
BAD INPUT, RETYPE FRØM ITEM 6
??
   .0001       , .0001
?
  10   , 10   , 1    , 1    , 1
?
 10000000000100000000001000000000010000000000100000
?
 00000100000000001000000000010000000000100000000001
?
 1100100001111000000000111000000000111000001001110001
?
 00001110000000001110000000001110000000001111000100011
INITIALIZING INPUT Ø.K
PREPARE TØ INPUT THE NETWØRK EVALUATIØN DATA
?2.3,.15,1.5,2.4,4.8,.999,.865
?
 2.6,.18,2.0,2.0,4.0,.998,.840
?
 2.8,.11,1.4,1.9,3.9,.999,.865
?
 1.9,.09,1.7,2.7,5.7,.998,.872
?
 3.0,.04,1.1,3.5,4.8,.801,.720
?
 3.1,.25,1.5,2.6,5.0,.993,.884
?
 2.4,.20,1.8,2.5,5.2,.998,.868
?
 2.6,.17,1.2,2.5,5.1,.996,.825
```

Then, the network evaluation parameters are loaded.

NAC INPUT O.K
SIMULATION TIME: 1968.1
READY
RECCOMMEND ACCEPT CHANGE: Z= 137390.
COMMAND?R
REPORT #?7

INEC analyzes the network analysis and immediately recommends to either accept or reject the change. The user then accesses several reports to aid in the decision.

---------- NETWORK PERFORMANCE OUTPUTS ----------

	OLD	NEW	DIFF	RATIO
MEAN PATH LENGTH	.0001	2.5	2.4999	25000
AVERAGE CAPACITY	.0001	.17	.1699	1700.
PEAK CAPACITY	.0001	1.7	1.6999	17000
AVERAGE DELAY	.0001	2.5	2.4999	25000
PEAK DELAY	.0001	5	4.9999	50000.
AVERAGE RELIABILITY	.0001	.999	.9989	9990
MINIMUM RELIABILITY	.0001	.87	.8699	8700

COMMAND?R
REPORT #?9

---------- NEW ECONOMIC REPORT ----------

IMP #	CONTRIBUTION	MARKET SHARE	REVENUE	PROFIT (LOSS)
1	52.3536	.115943	8692.51	1195.28
2	49.9216	.110557	8288.68	791.451
3	18.9331	4.19293E-02	3143.54	-4353.69
4	57.9806	.128404	9626.75	2129.52
5	7.66811	1.69818E-02	1273.17	-6224.06
6	74.2119	.16435	12321.7	4824.47
7	90.8122	.201113	15077.9	7580.68
8	44.1916	9.78669E-02	7337.31	-159.922
9	19.1409	4.23895E-02	3178.04	-4319.19
10	36.334	8.04654E-02	6032.67	-1464.55

COMMAND?R
REPORT #?10

---------- NETWORK SUMMARY ----------

	TOTAL NETWORK TRAFFIC	AVERAGE IMP TRAFFIC	TOTAL NETWORK REVENUE	AVERAGE IMP REVENUE
OLD	1	.1	1	.1
NEW	3748.61	374.861	74972.3	7497.23
RATIO	3748.61		74972.3	

```
COMMAND?G
PROPOSED CHANGE IMPLEMENTED
```

After reviewing the reports the user decides to implement the change.

Appendix F

USER'S MANUAL TO INEC ("INDEPENDENT NODES ECONOMICS SIMULATION MODEL")

by

MARC U. PORAT

****

INDEPENDENT NODES ECONOMICS (INEC) SIMULATION MODEL
USER'S MANUAL
CABLEDATA ASSOCIATES
PALO ALTO, CALIFORNIA
VERSION: AUG 8, 1973
MARC U. PORAT

****

TABLE OF CONTENTS

TO ACCESS PORTIONS OF THE USER'S MANUAL, PLEASE TYPE THE SECTION NUMBER, E.G. 5.2 OR 3.0 (IN THE LATTER CASE, YOU WILL RECEIVE ALL CONTENTS OF SECTION 3.0). IF YOU WANT THE WHOLE MANUAL, PLEASE TYPE 'ALL'.

TYPE 'DONE' WHEN YOU HAVE FINISHED BROWSING THE USER'S MANUAL AND ARE READY TO RETURN TO THE MAIN PROGRAM.

ALL *(USER RESPONSE)*

1.0 INTRODUCTION

THE INEC MODEL WAS DESIGNED PRIMARILY AS A GAMING TOOL FOR NETWORK SIMULATIONS. THE PLAYERS IN THE GAME ARE ENTREPENEURS: OWNERS OF IMPS OR IMP SUB-NETS, AND OWNERS OF HOST MACHINES. THE PURPOSE OF THE GAME IS TO TAKE AN EXISTING NETWORK (MINIMAL), AND INTRODUCE SUCCESSFUL CHANGES IN THE NETWORK TOPOLOGY SUCH THAT THE NETWORK'S PERFORMANACE AS A WHOLE IS IMPROVED. EACH PLAYER, REPRESENTING A SUB-NET IN A COMBINED NETWORK, HAS THE OBJECTIVE OF MAXIMIZING HIS SALES OR PROFIT. THEREFORE, A 'GOOD' CHANGE FROM INEC'S POINT OF VIEW IS ONE WHICH INCREASES BOTH THE MEMBER'S ECONOMIC POSITION AND THE COMBINED NETWORK'S TOTAL TRAFFIC OR REVENUE.

A FULL DISCUSSION OF THE ASSUMPTIONS WHICH UNDERLIE THIS APPROACH MAY BE OBTAINED FROM CABLEDATA ASSOCIATES:

WP 101	GOLDSTEIN	THE PROPOSED ARPANET DIVESTITURE: LEGAL QUESTIONS & ECONOMIC ISSUES
WP 102	PORAT	A DECISION TREE ADDENDUM TO CAWP 101
WP 111	PORAT	A DELPHI EXERCIZE EXAMINING FOUR ALTERNATIVE COMMUNICATIONS POLICY OPTIONS
WP 112	BARAN PORAT	PRELIMENARY CONCEPT DRAFT FOR A REQUEST FOR PROPOSAL FOR THE ARPANET
WP 113	PORAT	ON FORMATION OF A COMMON INTEREST CONSORTIUM OF PACKET-SWITCHING ENTITIES
WP 114	CERF	TOWARD A DIVESTITURE PLAN FOR THE ARPANET

THE FOLLOWING IS A THUMBNAIL SUMMARY OF THE ASSUMPTIONS:

1.1 ALL NODES (OR IMPS) ARE UNDER INDEPENDENT OWNERSHIP.
1.2 A PLAYER MAY OWN MORE THAN ONE, BUT NOT ALL, IMPS.
1.3 THE IMP OWNERS ARE IN COMPETITION WITH EACH OTHER FOR A SHARE OF THE REVENUE.
1.4 AN IMP'S SHARE OF THE PIE IS COMPLETELY DETERMINED BY ITS CONTRIBUTION TO THE NETWORK, I.E., ITS LOCATION IN THE NET AND ITS LINKAGES
1.5 AN ENTREPENEUR MAY IMPROVE HIS IMP'S CONTRIBUTION BY REARRANGING ITS LOCATION OR LINKAGES.
1.6 ALL THE IMP OR SUBNET OWNERS ARE FULL MEMBERS IN A PACKET CONSORTIUM. THE CONSORTIUM SERVES IN TWO MAJOR FUNCTIONS : A) AS A PAYMENTS CLEARINGHOUSE IN THE EVENT THAT TRAFFIC FLOWS THROUGH SEVERAL INDEPENDENT NETWORKS, AND B) AS A COORDINATING MECHANISM TO INSURE THE SMOOTH OPERATION OF A COMBINED NETWORK, IN PARTICULAR, INTERFACE STANDARDS AND MANAGERIAL SERVICES.

2.0 LOADING THE MODEL

TO RUN THE MODEL, TYPE 'GET-*INEC'. YOUR TERMINAL SHOULD BE EQUIPPED WITH A CASETTE MEMORY OR PAPER-TAPE DEVICE. TYPE 'RUN'. YOU WILL BE PROMPTED WITH THE FOLLOWING QUESTION: 'IS THIS A NEW (0) OR CONTINUATION (1) RUN?' IF YOU DON'T KNOW, TYPE '0'; IF YOU HAVE PLAYED THE GAME BEFORE, AND HAVE A PHYSICAL RECORD OF IT, TYPE '1'.

2.1 INITIALIZING A NEW RUN

IF YOU TYPED '0', THE SYSTEM WILL BE AUTOMATICALLY LOADED WITH A STANDARD STARTING TOPOLOGY CONSISTING OF A TEN NODE NETWORK WITH NO LINKAGES.

YOU ARE NOW FREE TO ADD OR DELETE IMPS AND LINKS TO THE STARTING TOPOLOGY UNTIL MAXIMUM REVENUES ARE ACHIEVED.

2.2 INITIALIZING A CONTINUATION RUN

THE MACHINE WILL PROMPT YOU TO 'PREPARE TO INPUT YOUR OLD TAPE OR CASETTE'. THIS IS THE PHYSICAL RECORD OF A PREVIOUS RUN, I.E., YOU ARE PICKING UP WHERE YOU LEFT OFF LAST TIME. AFTER YOUR OLD DATA IS LOADED INTO THE MODEL, IT WILL CRANK ITSELF UP TO SPEED AND ADVISE YOU THAT IT IS 'READY'. AT THIS POINT, ALL THE ECONOMIC REPORTS ARE PREPARED, AND YOU MAY ACCESS THEM AT WILL (SEE SECTION 4.0).

3.0 ALTERING THE NETWORK

3.1 IMP ADDITIONS AND DELETIONS

ANY OPERATION INVOLVING AN IMP IS ANNOUNCED TO THE MODEL BY INPUTING AN 'I' TO THE 'COMMAND' PROMPT. THE MACHINE WILL THEN REQUEST AN 'A' OR A 'D' TO SIGNIFY A ADDITION OR DELETION ON THE IMP INVENTORY. THE THIRD INSTRUCTION REQUESTED IS THE IMP NUMBER:

```
COMMAND?  I
IMP ADD/DELETE?  A
IMP #?  2
```

IN THE ABOVE EXAMPLE, THE USER REQUESTED TO ADD IMP #2 TO THE INVENTORY. IF THE OPERATION WAS SUCCESSFUL, THE SYSTEM WILL TO INFORM THE USER. AN OPERATION WILL BE UNSUCCESSFUL IN TWO CASES: (A) ATTEMPTING TO ADD AN ALREADY EXISTING IMP, AND (B) ATTEMPTING TO DELETE AN NONEXISTING IMP. IF THE USER IS UNCLEAR AT ANY POINT DURING THE SIMULATION WHICH IMPS EXIST, REPORTS #5 & 6 SHOULD BE CALLED (SEE SECTION 4.0).

WHENEVER AN IMP IS DROPPED, ALL THE LINKS INVOLVING THAT IMP WILL ALSO BE DROPPED AUTOMATICALLY. THE MODEL WILL INFORM THE USER WHICH LINKS ARE BEING DROPPED.

3.2 LINK ADDITIONS AND DELETIONS

THE OPERATIONS INVOLVING LINKS ARE SIMILAR TO THE IMP OPERATIONS. IN RESPONSE TO THE 'COMMAND' PROMPT, THE USER ENTERS 'L' TO SIGNIFY LINK OPERATIONS. THE NEXT INSTRUCTION SHOULD BE A 'A' OR 'D' TO SIGNIFY ADDITIONS OR DELETIONS. THE THIRD ENTRY SHOULD BE AN IMP PAIR -- TWO NUMBERS, SEPERATED BY COMMAS.

```
COMMAND?   L
LINK ADD/DELETE?   D
LINK #'S?   3,8
```

UNSUCCESSFUL ADD OR DELETE OPERATIONS CAN OCCUR IN FOUR CASES: (A) ATTEMPTING TO ADD A LINK TO A NONEXISTING IMP (B) ATTEMPTING TO ADD AN ALREADY EXISTING LINK, (C) ATTEMPTING TO DROP A LINK FROM A NONEXITING IMP, OR (D) ATTEMPTING TO DROP A NONEXISTING LINK. THE SYSTEM WILL INFORM THE USER IN THESE CASES. SHOULD THE USER REQUIRE THE NETWORK TOPOLOGY, REPORTS #3 AND 4 ARE AVAILABLE (SEE SECTION 4.0).

4.0 REPORT GENERATION

A USER MAY CALL ANY OF THE TEN REPORTS AVAILABLE BY INPUTING 'R' (REPORT) FOLLOWED BY A NUMBER. E.G.

```
      ? R            ? R
      ? 9            ?  3
```

THE AVAILABLE REPORTS ARE:

REPORT	OLD (EXISTING)	NEW (PROPOSED)
TRAFFIC DEMAND	1	2
NETWORK TOPOLOGY	3	4
IMPS INVENTORY	5	6
NETWORK PERFORMANCE	7	
SALES ANALYSIS	8	9
NETWORK SUMMARY	10	

THE DISTINCTION BETWEEN 'OLD' AND 'NEW' SHOULD BE CLEARLY UNDERSTOOD BY THE USER. THE SIMULATION BEGINS WITH AN 'OLD' NETWORK. THE USER IS FREE TO ALTER THE NETWORK BY ADDING OR DELETING AN IMP OR A LINK. AFTER A DISCRETE CHANGE IS PROPOSED, IT IS EVALUATED BY THE SYSTEM (SEE BELOW), AND A RECOMMENDATION IS ISSUED TO IMPLEMENT OR ABORT THE CHANGE. IF THE PROPOSED CHANGE IS IMPLEMENTED, THE 'OLD' SYSTEM IS SCRATCHED AND REPLACED BY THE 'NEW' SYSTEM. ONCE THAT OPERATION HAS TAKEN PLACE, A COPY IS MADE OF THE UPDATED OLD SYSTEM, AND IT IS CALLED THE 'NEW' SYSTEM. FROM THE USER'S POINT OF VIEW, 'OLD' REPORTS SHOULD BE CALLED WHEN A NEED ARISES TO REVIEW THE EXISTING SYSTEM, AND 'NEW' REPORTS SHOULD BE CALLED WHEN THE USER WISHES TO REVIEW HIS (HER) OWN CHANGES BEFORE IMPLEMENTATION.

A MORE TERSE VERSION OF THE ABOVE PARAGRAPH IS OFFERED:

```
CYCLE 1    OLD 1  +  CHANGES   =  NEW 1
           NEW 1  +  APPROVAL  =  OLD 2
CYCLE 2    OLD 2  +  CHANGES   =  NEW 2
           NEW 2  +  APPROVAL   =  OLD 3     ETC.
```

ONCE A CYCLE IS COMPLETED, THE PREVIOUS 'OLD' FILES ARE ERASED.

5.0 SAVING A FILE

5.1 THE HALF-FILE

WHEN THE USER HAS PROPOSED A CHANGE IN THE NETWORK TOPOLOGY, THE MODEL WILL PROMPT: 'MODEL EVALUATIONS'. IF ALL THE DESIRED CHANGES HAVE BEEN MADE, THE USER MAY RESPOND 'YES'. AT THIS POINT, THE USER SHOULD PREPARE TO OUTPUT A FILE OF SYSTEM DATA ONTO A PAPER TAPE OR CASETTE TAPE. ALL THE OLD TECHNICAL AND ECONOMIC REPORTS WILL BE DUMPED OUT, IN PREPARATION FOR A CONTINUATION RUN LATER ON. THIS PHYSICAL RECORD WILL BE USED TO RELOAD A CONTINUATION RUN.

AFTER THE FIRST FILE IS MADE, THE USER WILL BE PROMPTED TO MAKE A MODEL EVALUATION FILE. THIS FILE WILL BE SENT TO A NETWORK EVALUATION MODEL WHICH WILL COMPUTE NEW TECHNICAL PARAMETERS FOR THE SYSTEM.

5.2 THE FULL FILE

AFTER THE NETWORK EVALUATIONS RETURN AND THE CONTINUATION RUN EXECUTED, THE USER MAY CHOOSE TO SAVE A FULL FILE AS THE STARTING POINT FOR THE NEXT RUN. THE FULL FILE CONTAINS ALL TECHNICAL AND ECONOMIC REPORTS, WITH THE PREVIOUS PROPOSED CHANGES EVALUATED, APPROVED, AND IMPLEMENTED. THE 'NEW' FILES ARE ZEROED, SO THAT THE FULL FILE IS APPROPRIATE FOR A CONTINUATION RELOAD.

6.0 NETWORK EVALUATION

THE PORTION OF THE HALF-FILE (SEE SECTION 5.1) COMPOSED OF THE PROPOSED NETWORK TOPOLOGY AND THE TRAFFIC DEMAND MATRIX IS SENT FOR TECHNICAL EVALUATION. THE ANALYSIS RETURNS OF PERFORMANCE DATA WHICH LATER FORMS THE BASIS FOR COMPUTING EACH IMP'S CONTRIBUTION TO THE NETWORK UNDER THE GIVEN TOPOLOGY. THE RELATIVE IMP CONTRIBUTIONS THEN ARE USED IN COMPUTING EACH IMP'S REVENUE SHARE. THE PARAMETERS USED IN THE NETWORK EVALUATION ARE:

(1) MEAN PATH LENGTH (TRAFFIC WEIGHTED)
(2) AVERAGE CAPACITY " "
(3) PEAK CAPACITY " "
(4) AVERAGE DELAY " "
(5) PEAK DELAY " "
(6) GLOBAL RELIABILITY " "
(7) DELTA GLOBAL RELIABILITY " "

THE ANALYSIS IS CONDUCTED BY CONSIDERING THE NETWORK IN AN ITERATIVE FASHION WITH ONE IMP DELETED FROM THE TOPOLOGY. THIS METHOD REVEALS EACH IMP'S IMPACT ON THE NETWORK AS A WHOLE, HENCE ITS CONTRIBUTION. THE LAST ITERATION CONSIDERS THE ENTIRE NETWORK, WITH ALL IMPS INCLUDED.

7.0 IMPLEMENTING OR ABORTING A PROPOSED CHANGE

THIS IS THE LAST STAGE IN ONE CYCLE OF THE SIMULATION. THE USER HAS GONE THROUGH THE FOLLOWING STAGES:

(A) INITIALIZED THE MODEL
(B) PROPOSED NETWORK CHANGES (IMPS AND LINKKS)
(C) PRODUCED A HALF-FILE, SENDING A PORTION FOR EVALUATION AND RETAINING A PORTION FOR THE CONTINUATION RUN
(D) RECEIVED THE NETWORK EVALUATIONS
(E) RE-INITIALIZED THE MODEL USING THE HALF-FILE AND THE NETWORK EVALUATION STATISTICS
(F) INSPECTED ALL THE NECESSARY TECHNICAL AND ECONOMIC REPORTS TO COMPARE THE OLD SYSTEM WITH THE NEW SYSTEM

AFTER THE HALF-FILE AND NETWORK EVALUATIONS ARE LOADED, THE MODEL WILL AUTOMATICALLY OFFER A RECOMMENDATION TO EITHER ACCEPT OR REJECT THE PROPOSED CHANGE. THE ACCEPTANCE ALGORITHM USES TWO CRITERIA: (A) DOES THE REVENUE AND/OR TRAFFIC INCREASE AS A RESULT OF THE PROPOSED CHANGE? (B) DOES ANY DEGREDATION IN SYSTEM PERFORMANCE OCCUR? THE MODEL COMPUTES WEIGHTED RATIOS OF THESE PARAMETERS, AND COMPUTES A 'Z' SCORE. THE USER MAY THEN CHOSE TO IMPLEMENT THE CHANGE, BY TYPING 'GO', OR ABORT THE CHANGE BY TYPING 'NOGO'. IN THE CURRENT VERSION OF THE MODEL, A USER IS FREE TO IGNORE THE MODEL RECOMMENDATION ENTIRELY, AND IMPLEMENT OR REJECT SOLELY ON HIS OWN JUDGMENT. A TYPICAL CONVERSATIOON MIGHT BE:

```
LOAD OLD CASTTE OR PAPER TAPE FOR CONTINUATION RUN
(USER LOADS OLD RECORD, AND ACTIVATES INPUT)
LOAD NAC EVALUATIONS CASETTE OR PAPER TAPE
(USER LOADS NAC EVALUATIONS AND ACTIVATES INPUT)
 RECOMMEND ACCEPT CHANGE   Z=1.34
 TYPE 'GO' OR 'NOGO'
 GO
 PROPOSED CHANGE IMPLEMENTED
```

AFTER A PROPSED CHANGE HAS BEEN THUS IMPLEMENTED, THE 'OLD' FILE IS ALTERED TO REFLECT THE NEW CHANGES, AND THE CYCLE BEGINS FROM THE BEGINNING.

9.0 INEC DICTIONARY

THE USER WILL FREQUENTLY BE PROMPTED FOR INPUT TO CONTROL THE MODEL OPERATION. WHEN THE MODEL IS IN THE COMMAND MODE, ANY OF THE FOLLOWING INPUTS MAY BE USED: (TYPING THE FIRST LETTER ONLY IS SUFFICIENT)

A=A(DD)	TO ADD AN IMP OR A LINK.
D=D(ELETE)	TO DELETE AN IMP OR A LINK.
E=E(VALUATE)	TO SEND THE PROPOSED CHANGES TO THE NETWORK EVALUATION MODEL.
G=G(O)	TO APPROVE AND IMPLEMENT A PROPOSED CHANGE FOLLOWING A MODEL EVALUATION.
I=I(MP)	TO INITIATE AN IMP OPERATION SEQUENCE.
L=L(INK)	TO INITIATE A LINK OPERATION SEQUENCE.
N=N(OGO)	TO REJECT AND ABORT A PROPOSED CHANGE FOLLOWING A MODEL EVALUATION.
R=R(EPORT)	TO CALL UP ONE OF THE TEN REPORTS.

REPORTS	OLD	NEW	BOTH
TRAFFIC DEMAND	1	2	
NETWORK TOPOLOGY	3	4	
IMPS INVENTORY	5	6	
NETWORK PERFORMANCE			7
ECONOMIC REPORTS	8	9	
NETWORK SUMMARY			10

T=T(IME)	TO BRING THE TRAFFIC DEMAND MATRIX UP TO ANY USER SPECIFIED TIME

THE USER WILL ALSO BE PROMPTED FOR 'YES' AND 'NO' ANSWERS, AND FOR A '0' OR '1' ANSWER. IF AN INPUT ERROR IS MADE, THE USER WILL USUALLY BE PUT BACK INTO THE COMMAND MODE FOLLOWING AN ERROR MESSAGE.

APPENDICES ON FACILITIES ECONOMICS ISSUES -- PREFACE

(Appendices G through J)

The following four appendices were prepared by Ronald C. Crane to describe a cost model structure for estimating the costs involved in the ARPANET. They provide a "do-it-yourself" kit of tools and a data base to allow the user to consider any combination of elements that are in place at any point in time, producing output analyses under a wide set of depreciation assumptions and costing bases.

Appendix G

ARPANET INVENTORY LISTING PROGRAM (RONA)

by

RONALD C. CRANE

PREFACE

This BASIC program is used to provide a listing of the facilities being considered in the financial analysis of the ARPANET.

The description of the forms of the output and the use of this program is contained in Appendix H, following.

While written for the HP2000F system, this program can be modified to run on other systems on line in the ARPANET, if required. Or, arrangements can be made to have access to these programs via the timesharing system used here.

ARPANET INVENTORY LISTING PROGRAM

FUNCTION

This program lists all of the sites in the network and the equipment at each site. General and development facilities are listed at the end of the printout. All the information comes from the data base contained in DATA-1 and DATA-2 programs, and is subsequently stored by FILMAK in the file FDATA.

TO USE PROGRAM RONA

To use the program to get a listing, log on to the time-sharing system and:

type GET-RONA (carriage return)

type RUN (carriage return)

The program will then run and produce about forty-five pages of output. If it does not run, or if you are not certain that the file FDATA is up to date, use FILMAK to reload the file.

The printout has dotted lines where the paper should be cut for eleven-inch pages. The pages may not be exact for terminals using friction feed. Page 1, Table of Contents, is printed at the end of the output.

SPECIAL NOTES

Parts of the output format require that the terminal have a backspace capability. What effect this has on terminals not equipped with backspace is not known at this time.

VARIABLES USED IN PROGRAM RONA

A	Date equipment was added (number of months after 1-1970)
B	Date equipment was removed (number of months after 1-1970)
C	Cost type (1=monthly, 2=investment, 3=sunk, non-recurring)
C1	Class listing flag
C2	Site flag
D(1)	Number of day in year (internal variable)
D(2)	Number of year (internal variable)
D(3)	Dummy variable for data routine
E	Equipment number
F$(35)	Equipment description (35 characters maximum)
G	Site number of equipment
H$(35)	Site name (10 characters maximum)
I	Connected site number (used in leased lines only, equals 0 otherwise)
I(1)	Month equipment installed
I(2)	Year equipment installed
I(3)	Month equipment removed
I(4)	Year equipment removed
I(5)	Month number of starting month
I(6)	Year of starting month
H1	High equipment class number of range being examined
L1	Line count on page
L2	Low equipment class number of range being examined
M$	Month of present date
P	Page count number
M1	Margin spacing (left hand margin)
S	Site number being examined

FILES USED IN THE PROGRAM RONA

File #1	FDATA - Semipermanent: contains data base for ARPANET
File #2	FILE2 - Temporary: used for accumulating the data on each site
File #3	FILE3 - Temporary: used for accumulating the Table of Contents as program progresses through data base

PDMA

```
10  REM ++++++++++++++++++++++ Today's Date ++++++++++++++++++++++++++++++
20  IF TIM(3)/4=INT(TIM(3)/4) THEN 40
30  GOTO 50
40  D[3]=1
50  D[3]=0
60  D[2]=TIM(3)+1900
70  D[1]=TIM(2)
80  IF D[1] <= 31 THEN 230
90  D[1]=D[1]+D[3]
100  IF D[1] <= 59 THEN 250
110  IF D[1] <= 90 THEN 280
120  IF D[1] <= 120 THEN 310
130  IF D[1] <= 151 THEN 340
140  IF D[1] <= 181 THEN 370
150  IF D[1] <= 212 THEN 400
160  IF D[1] <= 243 THEN 430
170  IF D[1] <= 273 THEN 460
180  IF D[1] <= 304 THEN 490
190  IF D[1] <= 334 THEN 520
200  D[1]=D[1]-334
210  M$="December"
220  GOTO 550
230  M$="January"
240  GOTO 550
250  D[1]=D[1]-31
260  M$="February"
270  GOTO 550
280  D[1]=D[1]-59
290  M$="March"
300  GOTO 550
310  D[1]=D[1]-90
320  M$="April"
330  GOTO 550
340  D[1]=D[1]-59
350  M$="May"
360  GOTO 550
370  D[1] D[1]-151
380  M$="June"
390  GOTO 550
400  D[1]=D[1]-181
410  M$="July"
420  GOTO 550
430  D[1]=D[1]-212
440  M$="August'
450  GOTO 550
460  D[1]=D[1]-243
470  M$="September"
480  GOTO 550
490  D[1]=D[1]-273
500  M$="October"
510  GOTO 550
520  D[1]=D[1]-304
530  M$="November"
540  DIM M$[15]
550  REM*************** END OF Today's Date SECTION ***********************
560  REM************************ TITLE PAGE ******************************
```

```
570  PRINT "-----"
580  PRINT LIN(19)
590  PRINT "                          CABLEDATA ASSOCIATES INC."
600  PRINT LIN(2)
610  PRINT "                             ARPANET INVENTORY"
620  PRINT LIN(5)
630  PRINT "                          ";M$;SPA(1);D[1];", ";D[2]
640  PRINT LIN(31)
650  PRINT "-----"
660  PRINT LIN(3);
670  L1=4
680  REM  ************************ END OF TITLE PAGE ******************
690  FILES FDATA,FILE2,FILE3
700  P=2
710  DIM F$[35],H$[35]
720  GOSUB 3610
730  REM ******************** ITEM DATE SECTION (SUBROUTINE) ***********
740  REM      I(1)=MONTH INSTALLED      I(2)=YEAR INSTALLED
750  REM      I(3)=MONTH REMOVED        I(4)=YEAR REMOVED
760  REM      I(5) = DATE OF MONTH 1      I(6) = YEAR OF MONTH 1
770  I[5]=0
780  I[6]=70
790  I[1]=A+I[5]
800  I[2]=INT(I[1]/12)+I[6]
810  I[1]=I[1]-12*(INT(I[1]/12))
820  I[3]=B+I[5]
830  I[4]=INT(I[3]/12)+I[6]
840  I[3]=I[3]-12*(INT(I[3]/12))
850  IF I[1]=0 THEN 870
860  GOTO 890
870  I[1]=12
880  I[2]=I[2]-1
890  IF I[3]=0 THEN 910
900  GOTO 930
910  I[3]=12
920  I[4]=I[4]-1
930  RETURN
940  REM ***************** END OF ITEM DATE SECTION ********************
950  REM ********************* MARGIN SUBROUTINE ***********************
960  M1=6
970  PRINT SPA(M1);
980  RETURN
990  REM ******************* END OF MARGIN SUBROUTINE ******************
1000  REM******************** PAGE END SUBROUTINE **********************
1010  PRINT LIN(63-L1);
1020  GOSUB 960
1030  PRINT "                  CABLEDATA ASSOCIATES, INC.        PAGE ";P
1040  GOSUB 960
1050  PRINT "                  ";M$;" ";D[1];", ";D[2]
1060  P=P+1
1070  PRINT LIN(1);
1080  PRINT "-----"
1090  PRINT LIN(3);
1100  L1=4
1110  RETURN
1120  REM        P (PAGE NUMBER) IS SET TO 1 AT THE BEGINNING OF PROGRAM
1130  REM ****************** END OF PAGE END SUBROUTINE ***************
1140  REM ************** LOAD SITE INVENTORY INTO FILE 2 ***************
```

```
1150  REM                        & PRINT TOP OF PAGE
1160  REM                   ALSO LOADS FILE # 3.   THE TABLE OF CONTENTS FIL
1170  REM        S = SITE NUMBER          C2 = SITE FLAG
1180  FOR S=1 TO 99
1190  REM  RESET FILES #1 & 2
1200  READ #1,1
1210  READ #2,1
1220  C2=0
1230  IF TYP(1)=3 THEN 1330
1240  READ #1;A,B,C,D,E,F$,G,H$,I
1250  IF G=S THEN 1300
1260  IF E >= 100 AND E<150 THEN 1280
1270  GOTO 1290
1280  IF I=S THEN 1300
1290  GOTO 1230
1300  PRINT #2;A,B,C,D,E,F$,G,H$,I, END
1310  C2=1
1320  GOTO 1230
1330  REM        +++++++++++  END OF THIS SUBSECTION TO LOAD FILE 2 +++++
1340  IF C2=0 THEN 1500
1350  READ #2,1
1360  READ #2;A,B,C,D,E,F$,G,H$,I
1370  IF E<150 AND E >= 100 THEN 1360
1380  GOSUB 960
1390  PRINT "                  SITE NO. ";G;"  ";H$
1400  PRINT LIN(1);
1410  GOSUB 960
1420  PRINT "              SITE INVENTORY   ";M$;" ";D[1];", ";D[2]
1430  PRINT LIN(2);
1440  GOSUB 960
1450  PRINT "EQUIPMENT CLASS"
1460  PRINT TAB(M1+1);"!"
1470  L1=11
1480  PRINT #3;G,H$,P, END
1490  GOSUB 2240
1500  NEXT S
1510  RETURN
1520  REM***************** END OF LOAD AND PAGE TOP SECTION ***********
1530  REM***************** CLASS LISTING SUBROUTINE ********************
1540  L1=L1+1
1550  C1=0
1560  REM C1 = FLAG INDICATING "NO ITEMS IN GROUP" FOR THIS SUBROUTINE
1570  READ #2,1
1580  IF TYP(2)=3 THEN 2090
1590  READ #2;A,B,C,D,E,F$,G,H$,I
1600  IF E >= L2 AND E<H1 THEN 1620
1610  GOTO 1580
1620  GOSUB 960
1630  GO[illegible]30
1640  IF E >= 100 AND E<150 THEN 1660
1650  GOTO 1[illegible]0
1660  IF I=S THEN 1690
1670  PRINT TAB(6+M1);"LINE TO ";H$;TAB(28+M1);I;
1680  GOTO 1720
1690  PRINT TAB(6+M1);"LINE TO ";F$;TAB(28+M1);G;
1700  GOTO 1720
1710  PRINT TAB(6+M1);F$;
1720  PRINT  USING 1730;TAB(34+M1),I[1],TAB(36+M1),I[2],TAB(42+M1)
```

```
1730  IMAGE #,2D,"-",2D
1740  IF B=999 THEN 1770
1750  PRINT  USING 1730;I[3],TAB(44+M1),I[4]
1760  GOTO 1780
1770  PRINT "-----";
1780  PRINT TAB(51+M1);"$";
1790  PRINT  USING 1830;D
1800  IF D<1000 THEN 1880
1810  IF D<1.E+06 THEN 1850
1820  PRINT  USING 1860
1830  IMAGE #,DDXDDDXDDD
1840  GOTO 1880
1850  PRINT  USING 1870
1860  IMAGE,#,""
1870  IMAGE,#,""
1880  IF C=1 THEN 1910
1890  IF C=2 THEN 1940
1900  IF C=3 THEN 1970
1910  PRINT  USING 1920
1920  IMAGE " /MONTH"
1930  GOTO 2030
1940  PRINT  USING 1950
1950  IMAGE " INVESTMENT"
1960  GOTO 2030
1970  IF G=99 THEN 2000
1980  PRINT  USING 2020
1990  GOTO 2030
2000  PRINT  USING 2010
2010  IMAGE " TOTAL"
2020  IMAGE " NON-RECUR."
2030  L1=L1+1
2040  C1=1
2050  IF L1 >= 60 THEN 2070
2060  GOTO 2080
2070  GOSUB 1000
2080  GOTO 1580
2090  IF C1=0 THEN 2110
2100  GOTO 2140
2110  GOSUB 960
2120  PRINT "                              --  NONE  -- "
2130  L1=L1+1
2140  PRINT LIN(1);
2150  L1=L1+1
2160  REM    RESET FILE POINTER
2170  READ #2,1
2180  IF H1=1000 THEN 2220
2190  IF L1 >= 55 THEN 2210
2200  GOTO 2220
2210  GOSUB 1000
2220  RETURN
2230  REM ****************** END OF CLASS LISTING SUBROUTINE *************

2240  REM ***++++++++++++++++  CLASS TITLE AND CONTROL SECTION *********
2250  GOSUB 960
2260  PRINT "100 =========== LEASED LINES ===="
2270  L2=100
2280  H1=150
2290  PRINT LIN(1);
2300  GOSUB 960
```

```
2310  PRINT  USING 2320
2320  IMAGE #,9X,"LINE",11X,"█ CONNECT █DATE  █ DATE   █ "
2330  PRINT  USING 2340
2340  IMAGE 5X,"COST     TYPE"
2350  GOSUB 960
2360  PRINT  USING 2370
2370  IMAGE 22X,"█ SITE NO.█ADDED █REMOVED █"
2380  PRINT LIN(1);
2390  L1=L1+4
2400  GOSUB 1530
2410  GOSUB 960
2420  PRINT "150 ================== MODEMS ===="
2430  H1=180
2440  L2=150
2450  GOSUB 1530
2460  GOSUB 960
2470  PRINT "180 ======== MODEM INTERFACES ===="
2480  H1=200
2490  L2=180
2500  GOSUB 1530
2510  GOSUB 960
2520  PRINT "200 ==================== IMPS ===="
2530  H1=300
2540  L2=200
2550  GOSUB 1530
2560  GOSUB 960
2570  PRINT "300 ==================== TIPS ===="
2580  H1=400
2590  L2=300
2600  GOSUB 1530
2610  GOSUB 960
2620  PRINT "400 === LOCAL TELEPHONE LINES ===="
2630  H1=450
2640  L2=400
2650  GOSUB 1530
2660  GOSUB 960
2670  PRINT "450 == LOCAL TELEPHONE MODEMS ===="
2680  H1=500
2690  L2=450
2700  GOSUB 1530
2710  GOSUB 960
2720  PRINT "500 =========== TIP TERMINALS ===="
2730  H1=600
2740  L2=500
2750  GOSUB 1530
2760  GOSUB 960
2770  PRINT "600 ========== HOST INTERFACE ===="
2780  H1=700
2790  L2=600
2800  GOSUB 1530
2810  GOSUB 960
2820  PRINT "700 ============ HOST MACHINE ===="
2830  H1=800
2840  L2=700
2850  GOSUB 1530
2860  GOSUB 960
2870  PRINT "800 ======== LOCAL FACILITIES ===="
2880  H1=900
```

```
2890  L2=800
2900  GOSUB 1530
2910  GOSUB 960
2920  PRINT "900 ========= LOCAL MANAGEMENT ===="
2930  H1=1000
2940  L2=900
2950  GOSUB 1530
2960  GOSUB 1000
2970  RETURN
2980  REM********** END OF CLASS TITLE AND CONTROL SECTION **************
2990  REM************* GENERAL FACILITIES LISTING SUBROUTINE ************
3000  REM          THESE FACILITIES ARE LISTED UNDER SITE NUMBER 99.
3010  READ #2,1
3020  READ #1,1
3030  GOSUB 960
3040  PRINT "                         GENERAL AND DEVELOPMENT FACILITIES"
3050  PRINT LIN(2);
3060  L1=8
3070  GOSUB 960
3080  PRINT  USING 3090
3090  IMAGE #,8X,"FACILITY",18X,"B DATE B  DATE  B "
3100  PRINT  USING 3120
3110  GOSUB 960
3120  IMAGE 5X,"COST    TYPE"
3130  PRINT  USING 3140
3140  IMAGE 34X,"BADDED BREMOVED B"
3150  PRINT LIN(1);
3160  GOSUB 960
3170  PRINT "000 == DEVELOPMENT FACILITIES ===="
3180  L1=12
3190  PRINT #3;0,"GENERAL & DEVELOPMENT FACILITIES",P, END
3200  IF TYP(1)=3 THEN 3260
3210  READ #1;A,B,C,D,E,F$,G,H$,I
3220  IF G=99 THEN 3240
3230  GOTO 3200
3240  PRINT #2;A,B,C,D,E,F$,G,H$,I, END
3250  GOTO 3200
3260  H1=50
3270  L2=1
3280  GOSUB 1530
3290  GOSUB 960
3300  PRINT  USING 3310
3310  IMAGE "050 ====== GENERAL FACILITIES ====="
3320  L2=50
3330  H1=100
3340  GOSUB 1530
3350  GOSUB 1000
3360  RETURN
3370  REM ****************** END OF GENERAL FACILITIES LISTING SUBROUTINI

3380  REM*************** TABLE OF CONTENTS SUBROUTINE *****************
3390  REM  FILE #3 IS A TEMPORARY FILE ALREADY LOADED WITH THE TABLE IN I
3400  READ #3,1
3410  P=1
3420  PRINT LIN(1);
3430  DIM B$[35]
3440  PRINT "                         ARPANET INVENTORY"
3450  PRINT LIN(5);
3460  PRINT "                         TABLE OF CONTENTS"
```

```
3470  PRINT LIN(3);
3480  PRINT TAB(15);"SITE NO.";TAB(28);"SITE NAME";TAB(58);"PAGE NO."
3490  PRINT LIN(2);
3500  L1=18
3510  IF TYP(3)=3 THEN 3580
3520  READ #3;A,B$,C
3530  PRINT TAB(15);A;TAB(20);B$;TAB(60);C
3540  L1=L1+1
3550  IF L1<60 THEN 3510
3560  GOSUB 1000
3570  GOTO 3510
3580  GOSUB 1000
3590  RETURN
3600  REM**************** END OF TABLE OF CONTENTS SUBROUTINE ***********
3610  GOSUB 1140
3620  GOSUB 2990
3630  GOSUB 3380
3640  END
```

Appendix H

ARPANET INVENTORY

by

RONALD C. CRANE

PREFACE

This report is prepared using the program RONA described in Appendix G, preceding.

This inventory listing shows the facilities that form the Communications part of the ARPANET. The program is capable of producing snap-shots of the network at any point in time.

In some instances the data needed was not readily available so estimates were made. However, the writer believes that these listings provide a reasonably accurate statement of the components of the communications-related components of the network adequate for economic analysis purposes.

In line with the limits of the present study, this inventory is restricted to the computer-communications portions of the ARPANET and purposely does not show or include the various host machines. This program has been written to include such facilities at a later date should it be desirable to do so.

TABLE OF CONTENTS

SITE NO. 1 UCLA

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED	COST	TYPE
100 ============ LEASED LINES ====					
LINE TO SDC	8	4-71	-----	$ 229	/MONTH
LINE TO UCSD	35	2-73	-----	$ 643	/MONTH
LINE TO UCSB	3	10-70	-----	$ 459	/MONTH
150 ================== MODEMS ====					
MODEM TO UCSB		9-70	-----	$ 425	/MONTH
MODEM TO UCSD		9-70	-----	$ 425	/MONTH
MODEM TO SDC		9-70	-----	$ 425	/MONTH
180 ======== MODEM INTERFACES ====					
MODEM INTERFACE UCSB		9-70	-----	$ 5,000	INVESTMENT
MODEM INTERFACE UCSD		9-70	-----	$ 5,000	INVESTMENT
MODEM INTERFACE SDC		9-70	-----	$ 5,000	INVESTMENT
200 =================== IMPS ====					
IMP		9-70	-----	$ 45,000	INVESTMENT
300 =================== TIPS ====					
-- NONE --					
400 === LOCAL TELEPHONE LINES ====					
-- NONE --					
450 == LOCAL TELEPHONE MODEMS ====					
-- NONE --					
500 =========== TIP TERMINALS ====					
-- NONE --					
600 ========== HOST INTERFACE ====					
HOST-IMP INTERFACE SFTWR		9-70	-----	$ 20,000	NON-RECUR.
HOST-IMP INT.SFTWR.360/91		9-70	-----	$ 20,000	NON-RECUR.
HOST-IMP INT.SFTWR.PDP-10		9-70	-----	$ 20,000	NON-RECUR.
HOST-IMP HDWR. INT. SIG.7		9-70	-----	$ 12,000	INVESTMENT
HOST-IMP HDWR. INT. 360/91		9-70	-----	$ 12,000	INVESTMENT
HOST-IMP HDWR.INT.PDP-10		9-70	-----	$ 12,000	INVESTMENT
700 ============ HOST MACHINE ====					
-- NONE --					

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.	9-70	-----	$	420 /MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

```
                    SITE NO.  2          SRI

              SITE INVENTORY   SEPTEMBER  26    ,  1973

EQUIPMENT CLASS
 :
100 ============ LEASED LINES ====

         LINE              8 CONNECT 8DATE  8 DATE   8       COST     TYPE
                           8 SITE NO.8ADDED 8REMOVED 8

       LINE TO LBL               34   12-72   -----     $       229 /MONTH
       LINE TO XROX              32   10-72   -----     $        86 /MONTH
       LINE TO AMST              16    8-72   -----     $        86 /MONTH

150 ================== MODEMS ====
       MODEM TO XEROX-PARC            10-70   -----     $       425 /MONTH
       MODEM TO LBL                   10-70   -----     $       425 /MONTH
       MODEM TO AMES                  10-70   -----     $       425 /MONTH

180 ======== MODEM INTERFACES ====
       MODEM INTERFACE X-PARC         10-70   -----     $     5,000 INVESTMENT
       MODEM INTERFACE AMES           10-70   -----     $     5,000 INVESTMENT
       MODEM INTERFACE LBL            10-70   -----     $     5,000 INVESTMENT

200 ==================== IMPS ====
        IMP                           10-70   -----     $    45,000 INVESTMENT

300 ==================== TIPS ====
                     --  NONE  --

400 === LOCAL TELEPHONE LINES ====
                     --  NONE  --

450 == LOCAL TELEPHONE MODEMS ====
                     --  NONE  --

500 =========== TIP TERMINALS ====
                     --  NONE  --

600 ========== HOST INTERFACE ====
       HOST-IMP INT. SFTWR.           10-70   -----     $    20,000 NON-RECUR.
       HOST-IMP INT.SFTWR.            10-70   -----     $    20,000 NON-RECUR.
       HOST-IMP HDWR. INT.            10-70   -----     $    12,000 INVESTMENT
       HOST-IMP HDWR.INT.             10-70   -----     $    12,000 INVESTMENT

700 ============ HOST MACHINE ====
                     --  NONE  --

800 ======== LOCAL FACILITIES ====
       LOCAL IMP MAINT.               10-70   -----     $       420 /MONTH
```

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE NO. 3 UCSB

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

Class	Line	Connect Site No.	Date Added	Date Removed		Cost	Type
100 ============ LEASED LINES ====							
	LINE TO UCLA	1	10-70	-----	$	459	/MONTH
	LINE TO FNWT	33	11-72	-----	$	1,147	/MONTH
150 ================== MODEMS ====							
	MODEM TO UCLA		11-70	-----	$	425	/MONTH
	MODEM TO FNWC		11-70	-----	$	425	/MONTH
190 ======== MODEM INTERFACES ====							
	MODEM INTERFACE		11-70	-----	$	5,000	INVESTMENT
	MODEM INTERFACE		11-70	-----	$	5,000	INVESTMENT
200 ==================== IMPS ====							
	IMP		11-70	-----	$	45,000	INVESTMENT
300 ==================== TIPS ====							
	-- NONE --						
400 === LOCAL TELEPHONE LINES ====							
	-- NONE --						
450 == LOCAL TELEPHONE MODEMS ====							
	-- NONE --						
500 =========== TIP TERMINALS ====							
	-- NONE --						
600 ========== HOST INTERFACE ====							
	HOST-IMP HDWR. INT.		11-70	-----	$	12,000	INVESTMENT
	HOST SOFTWARE MOD.		11-70	-----	$	20,000	NON-RECUR.
700 ============ HOST MACHINE ====							
	-- NONE --						
800 ======== LOCAL FACILITIES ====							
	LOCAL IMP MAINT.		11-70	-----	$	420	/MONTH
900 ======== LOCAL MANAGEMENT ====							
	-- NONE --						

SITE NO. 4 UTAH

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

EQUIPMENT CLASS / LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
100 ============ LEASED LINES ====						
LINE TO ILL	12	12-71	-----	$	6,597	/MONTH
LINE TO LBL	34	12-72	-----	$	3,442	/MONTH
150 ================== MODEMS ====						
MODEM TO LBL		12-70	-----	$	425	/MONTH
MODEM TO ILL		12-70	-----	$	425	/MONTH
180 ======== MODEM INTERFACES ====						
MODEM INTERFACE		12-70	-----	$	5,000	INVESTMENT
MODEM INTERFACE		12-70	-----	$	5,000	INVESTMENT
200 ==================== IMPS ====						
IMP		12-70	-----	$	45,000	INVESTMENT
300 =================== TIPS ====						
-- NONE --						
400 === LOCAL TELEPHONE LINES ====						
-- NONE --						
450 == LOCAL TELEPHONE MODEMS ====						
-- NONE --						
500 ========== TIP TERMINALS ====						
-- NONE --						
600 ========== HOST INTERFACE ====						
PDP-10 HDWR. INTERFACE		12-70	-----	$	12,000	INVESTMENT
PDP-10 SFTWR. MOD.		12-70	-----	$	20,000	NON-RECUR.
700 ============ HOST MACHINE ====						
-- NONE --						
800 ======== LOCAL FACILITIES ====						
LOCAL IMP MAINT.		12-70	-----	$	420	/MONTH
900 ======== LOCAL MANAGEMENT ====						
-- NONE --						

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO HARV	9	6-71	-----	$	57	/MONTH
LINE TO CCAT	31	8-72	-----	$	57	/MONTH

150 ================== MODEMS ====

MODEM TO CCA		4-71	-----	$	425	/MONTH
MODEM TO HARVARD		4-71	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

MODEM INTERFACE		4-71	-----	$	5,000	INVESTMENT
MODEM INTERFACE		4-71	-----	$	5,000	INVESTMENT

200 ==================== IMPS ====

IMP		4-71	-----	$	45,000	INVESTMENT

300 ==================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

HDWR. INT. 4 MACHINES		4-71	-----	$	48,000	INVESTMENT
SFTWR. MOD. 4 MACHINES		4-71	-----	$	80,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINTENANCE		4-71	-----	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO CCAT	31	8-72	-----	$	57	/MONTH
LINE TO LL	10	5-71	-----	$	114	/MONTH
LINE TO ILL	12	12-71	-----	$	5,450	/MONTH

150 ================== MODEMS ====

MODEM TO CCA		6-71	-----	$	425	/MONTH
MODEM TO LL		6-71	-----	$	425	/MONTH
MODEM TO ILL		6-71	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

MODEM INTERFACE		6-71	-----	$	5,000	INVESTMENT
2 MODEM INTERFACES		6-71	-----	$	10,000	INVESTMENT

200 =================== IMPS ====

IMP		6-71	-----	$	45,000	INVESTMENT

300 =================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

4 HDWR. INTERFACES		6-71	-----	$	48,000	INVESTMENT
4 SFTWR. MOD.		6-71	-----	$	80,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.		6-71	-----	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO ISI	22	8-72	-----	$	229	/MONTH
LINE TO UCSD	35	2-73	-----	$	860	/MONTH
150 ================== MODEMS ====						
MODEM TO UCSD		4-71	-----	$	425	/MONTH
MODEM TO ISI		4-71	-----	$	425	/MONTH
180 ======== MODEM INTERFACES ====						
MODEM INTERFACES (2)		4-71	-----	$	10,000	INVESTMENT
200 =================== IMPS ====						
IMP		4-71	-----	$	45,000	INVESTMENT
300 =================== TIPS ====						
-- NONE --						
400 === LOCAL TELEPHONE LINES ====						
-- NONE --						
450 == LOCAL TELEPHONE MODEMS ====						
-- NONE --						
500 =========== TIP TERMINALS ====						
-- NONE --						
600 ========== HOST INTERFACE ====						
HDWR. INTERFACE 360/65		4-71	-----	$	12,000	INVESTMENT
SFTWR. MOD. 360/65		4-71	-----	$	20,000	NON-RECUR.
700 ============ HOST MACHINE ====						
-- NONE --						
800 ======== LOCAL FACILITIES ====						
LOCAL IMP MAINT.		4-71	-----	$	420	/MONTH
900 ======== LOCAL MANAGEMENT ====						
-- NONE --						

SITE NO. 8 SDC

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO USCT	23	4-72	-----	$	258	/MONTH
LINE TO UCLA	1	4-71	-----	$	229	/MONTH

150 ================== MODEMS ====

MODEM TO USC		4-71	-----	$	425	/MONTH
MODEM TO UCLA		4-71	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		4-71	-----	$	10,000	INVESTMENT

200 ==================== IMPS ====

IMP		4-71	-----	$	45,000	INVESTMENT

300 ==================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

1 HDWR. INTERFACE 360/145		4-71	-----	$	12,000	INVESTMENT
1 SFTWR. MOD. 360/145		4-71	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.		4-71	-----	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE NO. 9 HARVARD

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED	COST	TYPE
100 ============ LEASED LINES ====					
LINE TO ABRD	29	7-72	-----	$ 2,151	/MONTH
LINE TO BBN	5	6-71	-----	$ 57	/MONTH
150 ================== MODEMS ====					
MODEM TO BBN #5		6-71	-----	$ 425	/MONTH
MODEM TO ABRD		6-71	-----	$ 425	/MONTH
180 ======== MODEM INTERFACES ====					
2 MODEM INTERFACES		6-71	-----	$ 10,000	INVESTMENT
200 ==================== IMPS ====					
IMP		6-71	-----	$ 45,000	INVESTMENT
300 ==================== TIPS ====					
-- NONE --					
400 === LOCAL TELEPHONE LINES ====					
-- NONE --					
450 == LOCAL TELEPHONE MODEMS ====					
-- NONE --					
500 =========== TIP TERMINALS ====					
-- NONE --					
600 ========== HOST INTERFACE ====					
3 HDWR. INTERFACES		6-71	-----	$ 36,000	INVESTMENT
3 SFTWR. MOD.		6-71	-----	$ 60,000	NON-RECUR.
700 ============ HOST MACHINE ====					
-- NONE --					
800 ======== LOCAL FACILITIES ====					
LOCAL IMP MAINT.		6-71	-----	$ 420	/MONTH
900 ======== LOCAL MANAGEMENT ====					
-- NONE --					

SITE NO. 10 LINCOLN LABS

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO MIT	6	5-71	-----	$	114	/MONTH

150 ================== MODEMS ====

MODEM TO MIT		5-71	-----	$	425	/MONTH
MODEM TO RADT		5-71	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

MODEM INTERFACE		5-71	-----	$	5,000	INVESTMENT
MODEM INTERFACE		5-71	-----	$	5,000	INVESTMENT

200 ==================== IMPS ====

IMP		5-71	-----	$	45,000	INVESTMENT

300 ==================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

3 HDWR. INTERFACES		5-71	-----	$	36,000	INVESTMENT
3 SFTWR. MOD.		5-71	-----	$	60,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.		5-71	-----	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

EQUIPMENT CLASS
:

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO AMES	15	8-72	-----	$	86	/MONTH
LINE TO ISI	22	8-72	-----	$	1,790	/MONTH

150 ================== MODEMS ====

MODEM TO AMES		7-71	-----	$	425	/MONTH
MODEM TO ISI		7-71	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		7-71	-----	$	10,000	INVESTMENT

200 ==================== IMPS ====

IMP		7-71	-----	$	45,000	INVESTMENT

300 ==================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

PDP-10 HDWR. INTERFACE		7-71	-----	$	12,000	INVESTMENT
PDP-10 SFTWR. MOD.		7-71	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.		7-71	-----	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO MIT	6	12-71	-----	$	5,450	/MONTH
LINE TO UTAH	4	12-71	-----	$	6,597	/MONTH

150 ================== MODEMS ====

MODEM TO UTAH		12-71	-----	$	425	/MONTH
MODEM TO MIT		12-71	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		12-71	-----	$	10,000	INVESTMENT

200 ==================== IMPS ====

IMP		12-71	-----	$	45,000	INVESTMENT

300 ==================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

PDP-11 HDWR. INTERFACE		12-71	-----	$	12,000	INVESTMENT
PDP-11 SFTWR. MOD.		12-71	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.		12-71	-----	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

```
EQUIPMENT CLASS
 :
100 ============ LEASED LINES ====

        LINE            ! CONNECT !DATE  ! DATE    !        COST    TYPE
                        ! SITE NO.!ADDED !REMOVED  !

     LINE TO CMU            14    11-71   -----    $        643 /MONTH
     LINE TO RADT           18    10-71   -----    $      2,008 /MONTH
     LINE TO GWCT           24     4-72   -----    $      5,450 /MONTH

150 ================== MODEMS ====
     MODEM TO GWCT                10-71   -----    $        425 /MONTH
     MODEM TO RADT                10-71   -----    $        425 /MONTH
     MODEM TO CMU                 10-71   -----    $        425 /MONTH

180 ======== MODEM INTERFACES ====
     3 MODEM INTERFACES           10-71   -----    $     15,000 INVESTMENT

200 =================== IMPS ====
     IMP                          10-71   -----    $     45,000 INVESTMENT

300 =================== TIPS ====
               -- NONE --

400 === LOCAL TELEPHONE LINES ====
               -- NONE --

450 == LOCAL TELEPHONE MODEMS ====
               -- NONE --

500 =========== TIP TERMINALS ====
               -- NONE --

600 ========== HOST INTERFACE ====
     PDP-10 HDWR. INT.            10-71   -----    $     12,000 INVESTMENT
     PDP-10 SFTWR. MOD.           10-71   -----    $     20,000 NON-RECUR.

700 ============ HOST MACHINE ====
               -- NONE --

800 ======== LOCAL FACILITIES ====
     LOCAL IMP MAINT.             10-71   -----    $        420 /MONTH

900 ======== LOCAL MANAGEMENT ====
               -- NONE --
```

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO BELV	27	6-72	-----	$	1,434	/MONTH
LINE TO CASE	13	11-71	-----	$	643	/MONTH
150 ================= MODEMS ====						
MODEM TO CASE		11-71	-----	$	425	/MONTH
MODEM TO BELV.		11-71	-----	$	425	/MONTH
180 ======== MODEM INTERFACES ====						
2 MODEM INTERFACES		11-71	-----	$	10,000	INVESTMENT
200 =================== IMPS ====						
IMP		11-71	-----	$	45,000	INVESTMENT
300 =================== TIPS ====						
-- NONE --						
400 === LOCAL TELEPHONE LINES ====						
-- NONE --						
450 == LOCAL TELEPHONE MODEMS ====						
-- NONE --						
500 =========== TIP TERMINALS ====						
-- NONE --						
600 ========== HOST INTERFACE ====						
3 HDWR. INTERFACES		11-71	-----	$	36,000	INVESTMENT
3 SFTWR. MOD.		11-71	-----	$	60,000	NON-RECUR.
700 ============ HOST MACHINE ====						
-- NONE --						
800 ======== LOCAL FACILITIES ====						
LOCAL IMP MAINT.		11-71	-----	$	420	/MONTH
900 ======== LOCAL MANAGEMENT ====						
-- NONE --						

SITE NO. 15 PAOLI,PENN.

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS
:
100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO STAN	11	8-72	-----	$	86	/MONTH

150 ================== MODEMS ====

2 MODEMS TO ANYWHERE		2-72	8-72	$	850	/MONTH
MODEM TO AMES TIP		8-72	-----	$	425	/MONTH
MODEM TO HAWTIP		8-72	-----	$	425	/MONTH
MODEM TO STANFORD		8-72	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		2-72	8-72	$	10,000	INVESTMENT
3 MODEM INTERFACES		8-72	-----	$	15,000	INVESTMENT

200 ==================== IMPS ====

IMP		2-72	8-72	$	45,000	INVESTMENT
IMP		8-72	-----	$	45,000	INVESTMENT

300 ==================== TIPS ====
-- NONE --

400 === LOCAL TELEPHONE LINES ====
-- NONE --

450 == LOCAL TELEPHONE MODEMS ====
-- NONE --

500 =========== TIP TERMINALS ====
-- NONE --

600 ========== HOST INTERFACE ====

1 HDWR. INTERFACE		2-72	8-72	$	12,000	INVESTMENT
1 SFTWR. MOD. ???		2-72	8-72	$	20,000	NON-RECUR.
2 HDWR. INTERFACES		8-72	-----	$	24,000	INVESTMENT
2 SFTWR. MOD.		8-72	-----	$	40,000	NON-RECUR.

700 ============ HOST MACHINE ====
-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.		2-72	8-72	$	420	/MONTH
LOCAL IMP MAINT		8-72	-----	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS
:
100 ============ LEASED LINES ====

LINE	$ CONNECT $ SITE NO.	$ DATE $ ADDED	$ DATE $ REMOVED	$ $	COST	TYPE
LINE TO SRI	2	8-72	-----	$	86	/MONTH

150 ================== MODEMS ====

MODEM TO AMES		8-72	-----	$	425	/MONTH
MODEM TO SRI		8-72	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		8-72	-----	$	10,000	INVESTMENT

200 ==================== IMPS ====
-- NONE --

300 ==================== TIPS ====

TIP		8-72	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====
-- NONE --

450 == LOCAL TELEPHONE MODEMS ====
-- NONE --

500 =========== TIP TERMINALS ====
-- NONE --

600 ========== HOST INTERFACE ====

1 HDWR. INTERFACE		8-72	-----	$	12,000	INVESTMENT
1 SFTWR. MOD.360/67		8-72	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====
-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		8-72	-----	$	585	/MONTH

900 ======== LOCAL MANAGEMENT ====
-- NONE --

SITE NO. 17 MITRE TIP

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO ARPT	28	6-72	-----	$	86	/MONTH
LINE TO SDAT	26	5-72	-----	$	172	/MONTH

150 ================== MODEMS ====

MODEM TO ARPA T		4-71	-----	$	425	/MONTH
MODEM TO SDAT		4-71	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		4-71	-----	$	10,000	INVESTMENT

200 ==================== IMPS ====

-- NONE --

300 ==================== TIPS ====

TIP		4-71	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

-- NONE --

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		4-71	-----	$	595	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS
:
100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO CASE	13	10-71	-----	$	2,008	/MONTH

150 ================== MODEMS ====

MODEM TO CASE		10-71	-----	$	425	/MONTH
MODEM TO LL		10-71	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		10-71	-----	$	10,000	INVESTMENT

200 ==================== IMPS ====
-- NONE --

300 ==================== TIPS ====

TIP		10-71	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====
-- NONE --

450 == LOCAL TELEPHONE MODEMS ====
-- NONE --

500 =========== TIP TERMINALS ====
-- NONE --

600 ========== HOST INTERFACE ====
-- NONE --

700 ============ HOST MACHINE ====
-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		10-71	-----	$	585	/MONTH

900 ======== LOCAL MANAGEMENT ====
-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

:

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO ABRD	29	7-72	-----	$	287	/MONTH

150 ================= MODEMS ====

MODEM TO ABRD		11-71	-----	$	425	/MONTH
MODEM TO ETAT		11-71	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		11-71	-----	$	10,000	INVESTMENT

200 =================== IMPS ====

-- NONE --

300 =================== TIPS ====

TIP		11-71	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

1 HDWR. INTERFACE		11-71	-----	$	12,000	INVESTMENT
1 SFTWR. MOD. PDP-11		11-71	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		11-71	-----	$	585	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO RMLT	37	2-73	-----	$	4,589	/MONTH
LINE TO ARPT	28	3-72	-----	$	143	/MONTH
LINE TO ARPT	28	6-72	-----	$	86	/MONTH

150 ================== MODEMS ====

MODEM TO NBS		3-72	-----	$	425	/MONTH
MODEM TO RMLT		3-72	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		3-72	-----	$	10,000	INVESTMENT

200 ==================== IMPS ====

-- NONE --

300 ==================== TIPS ====

TIP		3-72	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

-- NONE --

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		3-72	-----	$	595	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
-- NONE --						

150 ================== MODEMS ====

MODEM TO ???		2-72	2-73	$	425	/MONTH
MODEM TO ???		2-72	2-73	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		2-72	2-73	$	10,000	INVESTMENT

200 ==================== IMPS ====

IMP		2-72	2-73	$	45,000	INVESTMENT

300 ==================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

1 HDWR. INTERFACE		2-72	2-73	$	12,000	INVESTMENT
1 SFTWR. MOD.		2-72	2-73	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.		2-72	2-73	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE NO. 22 McCLELLAN

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO STAN	11	8-72	-----	$	1,790	/MONTH
LINE TO RAND	7	8-72	-----	$	229	/MONTH
LINE TO RMLT	37	2-73	-----	$	13,424	/MONTH

150 ================== MODEMS ====

MODEM TO ???		3-72	2-73	$	425	/MONTH
MODEM TO ???		3-72	2-73	$	425	/MONTH
MODEM TO RML		2-73	-----	$	425	/MONTH
MODEM TO RAND		2-73	-----	$	425	/MONTH
MODEM TO STAN		2-73	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2MODEM INTERFACES		3-72	2-73	$	10,000	INVESTMENT

200 =================== IMPS ====

IMP		3-72	2-73	$	45,000	INVESTMENT
IMP		2-73	-----	$	45,000	INVESTMENT

300 =================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 ========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

1 HDWR. INTERFACE		3-72	2-73	$	12,000	INVESTMENT
1 SFTWR. MOD.		3-72	2-73	$	20,000	NON-RECUR.
PDP-10 HDWR. INT.		2-73	-----	$	12,000	INVESTMENT
PDP-10 SFTWR. MOD.		2-73	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ========= LOCAL FACILITIES ----

LOCAL IMP MAINT.	3-72	2-73	$	420 /MONTH
LOCAL IMP MAINT.	2-73	-----	$	420 /MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO NOAT	25	2-70	-----	$	4,876	/MONTH
LINE TO SDC	8	4-72	-----	$	258	/MONTH

150 ================= MODEMS ====

MODEM TO SDC		4-72	-----	$	425	/MONTH
MODEM TO NOAT		4-72	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		4-72	-----	$	10,000	INVESTMENT

200 =================== IMPS ====

-- NONE --

300 =================== TIPS ====

TIP		4-72	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

1 HDWR. INTERFACE		4-72	-----	$	12,000	INVESTMENT
1 SFTWR. MOD. 360/44		4-72	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		4-72	-----	$	585	/MONTH

900 ======= LOCAL MANAGEMENT ====

-- NONE --

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO CASE	13	4-72	-----	$	5,450	/MONTH
LINE TO NOAT	25	5-72	-----	$	1,721	/MONTH
150 ================= MODEMS ====						
MODEM TO CASE		4-72	-----	$	425	/MONTH
MODEM TO NOAT		4-72	-----	$	425	/MONTH
180 ======== MODEM INTERFACES ====						
2 MODEM INTERFACES		4-72	-----	$	10,000	INVESTMENT
200 =================== IMPS ====						
-- NONE --						
300 =================== TIPS ====						
TIP		4-72	-----	$	92,000	INVESTMENT
400 === LOCAL TELEPHONE LINES ====						
-- NONE --						
450 == LOCAL TELEPHONE MODEMS ====						
-- NONE --						
500 =========== TIP TERMINALS ====						
-- NONE --						
600 ========== HOST INTERFACE ====						
-- NONE --						
700 ============ HOST MACHINE ====						
-- NONE --						
800 ======== LOCAL FACILITIES ====						
LOCAL TIP MAINT.		4-72	-----	$	585	/MONTH
900 ======== LOCAL MANAGEMENT ====						
-- NONE --						

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED	$	COST	TYPE
LINE TO GWCT	24	5-72	-----	$	1,721	/MONTH
LINE TO USCT	23	2-70	-----	$	4,876	/MONTH
150 ================= MODEMS ====						
MODEM TO GWCT		5-72	-----	$	425	/MONTH
MODEM TO USCT		5-72	-----	$	425	/MONTH
180 ======== MODEM INTERFACES ====						
2 MODEM INTERFACES		5-72	-----	$	10,000	INVESTMENT
200 =================== IMPS ====						
-- NONE --						
300 =================== TIPS ====						
TIP		5-72	-----	$	92,000	INVESTMENT
400 === LOCAL TELEPHONE LINES ====						
-- NONE --						
450 == LOCAL TELEPHONE MODEMS ====						
-- NONE --						
500 =========== TIP TERMINALS ====						
-- NONE --						
600 ========== HOST INTERFACE ====						
-- NONE --						
700 ============ HOST MACHINE ====						
-- NONE --						
800 ======== LOCAL FACILITIES ====						
LOCAL TIP MAINT		5-72	-----	$	585	/MONTH
900 ======== LOCAL MANAGEMENT ====						
-- NONE --						

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS
 !
100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO BELV	27	6-73	-----	$	287	/MONTH
LINE TO MTRT	17	5-72	-----	$	172	/MONTH

150 ================== MODEMS ====

MODEM TO BELV		5-72	-----	$	425	/MONTH
MODEM TO NSAT		5-72	-----	$	425	/MONTH
MODEM TO MTRT		5-72	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

3 MODEM INTERFACES		5-72	-----	$	15,000	INVESTMENT

200 ==================== IMPS ====

-- NONE --

300 ==================== TIPS ====

TIP		5-72	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

360/44 HDWR. INT.		5-72	-----	$	12,000	INVESTMENT
360/44 SFTWR. MOD.		5-72	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		5-72	-----	$	585	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

EQUIPMENT CLASS	LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
100 ============ LEASED LINES ====							
	LINE TO ABRD	29	7-72	-----	$	430	/MONTH
	LINE TO SDAT	26	6-73	-----	$	287	/MONTH
	LINE TO CMU	14	6-72	-----	$	1,434	/MONTH
150 ================== MODEMS ====							
	MODEM TO ABRD		6-72	-----	$	425	/MONTH
	MODEM TO CMU		6-72	-----	$	425	/MONTH
	MODEM TO SDAT		6-72	-----	$	425	/MONTH
180 ======== MODEM INTERFACES ====							
	3 MODEM INTERFACES		6-72	-----	$	15,000	INVESTMENT
200 ==================== IMPS ====							
	IMP		6-72	-----	$	45,000	INVESTMENT
300 ==================== TIPS ====							
	-- NONE --						
400 === LOCAL TELEPHONE LINES ====							
	-- NONE --						
450 == LOCAL TELEPHONE MODEMS ====							
	-- NONE --						
500 =========== TIP TERMINALS ====							
	-- NONE --						
600 ========== HOST INTERFACE ====							
	CDC 6600 HDWR. INT.		6-72	-----	$	12,000	INVESTMENT
	CDC 6600 SFTWR. MOD.		6-72	-----	$	20,000	NON-RECUR.
700 ============ HOST MACHINE ====							
	-- NONE --						
800 ======== LOCAL FACILITIES ====							
	LOCAL IMP MAINT.		6-72	-----	$	420	/MONTH
900 ======== LOCAL MANAGEMENT ====							
	-- NONE --						

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS
:

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO ETAT	20	3-72	-----	$	143	/MONTH
LINE TO ETAT	20	6-72	-----	$	86	/MONTH
LINE TO MTRT	17	6-72	-----	$	86	/MONTH

150 ================== MODEMS ====

MODEM TO MTRT		6-72	-----	$	425	/MONTH
MODEM TO ETAT		6-72	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		6-72	-----	$	10,000	INVESTMENT

200 ==================== IMPS ====

-- NONE --

300 ==================== TIPS ====

TIP		6-72	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

PDP-15 HDWR. INT.		6-72	-----	$	12,000	INVESTMENT
PDP-15 SFTWR. MOD.		6-72	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		6-72	-----	$	585	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE NO. 29 ABERDEEN

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO NBST	19	7-72	-----	$	287	/MONTH
LINE TO HARV	9	7-72	-----	$	2,151	/MONTH
LINE TO BELV	27	7-72	-----	$	430	/MONTH

150 ================== MODEMS ====

-- NONE --

180 ======== MODEM INTERFACES ====

3 MODEM INTERFACES		7-72	-----	$	15,000	INVESTMENT

200 ==================== IMPS ====

IMP		7-72	-----	$	45,000	INVESTMENT

300 ==================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

PDP-11 HDWR. INT.		7-72	-----	$	12,000	INVESTMENT
PDP-11 SFTWR. MOD.		7-72	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.		7-72	-----	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE NO. 30 BBN TIP

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

!

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED	COST	TYPE

-- NONE --

150 ================== MODEMS ====

-- NONE --

180 ======== MODEM INTERFACES ====

-- NONE --

200 =================== IMPS ====

-- NONE --

300 =================== TIPS ====

TIP		7-72	-----	$ 92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

-- NONE --

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		7-72	-----	$ 585	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO BBN	5	8-72	-----	$	57	/MONTH
LINE TO MIT	6	8-72	-----	$	57	/MONTH

150 ================== MODEMS ====

MODEM TO MIT 6		8-72	-----	$	425	/MONTH
MODEM TO BBN		8-72	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		8-72	-----	$	10,000	INVESTMENT
2 MODEM INTERFACES		8-72	-----	$	10,000	INVESTMENT

200 ==================== IMPS ====

-- NONE --

300 ==================== TIPS ====

TIP		8-72	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

PDP-10 HDWR. INT.		8-72	-----	$	12,000	INVESTMENT
PDP-10 SFTWR. MOD.		8-72	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		8-72	-----	$	585	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE NO. 32 XEROX

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO SRI	2	10-72	-----	$	86	/MONTH
LINE TO FNWT	33	11-72	-----	$	344	/MONTH

150 ================== MODEMS ====

MODEM TO SRI		10-72	-----	$	425	/MONTH
MODEM TO FNWT		10-72	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

-- NONE --

200 ==================== IMPS ====

IMP		10-72	-----	$	45,000	INVESTMENT

300 ==================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

3 HDWR. INTERFACES		10-72	-----	$	36,000	INVESTMENT
3 SFTWR. MOD.		10-72	-----	$	60,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.		10-72	-----	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE NO. 33 FNWC TIP

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO UCSB	3	11-72	-----	$	1,147	/MONTH
LINE TO XROX	32	11-72	-----	$	344	/MONTH

150 ================== MODEMS ====

MODEM TO XROX		11-72	-----	$	425	/MONTH
MODEM TO UCSB		11-72	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		11-72	-----	$	10,000	INVESTMENT

200 ==================== IMPS ====

-- NONE --

300 ==================== TIPS ====

TIP		11-72	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

CDC 6500 HDWR. INT.		11-72	-----	$	12,000	INVESTMENT
CDC 6500 SFTWR. MOD.		11-72	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		11-72	-----	$	585	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

Equipment Class	Line	Connect Site No.	Date Added	Date Removed		Cost	Type
100 ============ LEASED LINES ====							
	LINE TO SRI	2	12-72	-----	$	229	/MONTH
	LINE TO UTAH	4	12-72	-----	$	3,442	/MONTH
150 ================= MODEMS ====							
	MODEM TO UTAH		12-72	-----	$	425	/MONTH
	MODEM TO SRI		12-72	-----	$	425	/MONTH
180 ======== MODEM INTERFACES ====							
	2 MODEM INTERFACES		12-72	-----	$	10,000	INVESTMENT
200 =================== IMPS ====							
	IMP		12-72	-----	$	45,000	INVESTMENT
300 =================== TIPS ====							
	-- NONE --						
400 === LOCAL TELEPHONE LINES ====							
	-- NONE --						
450 == LOCAL TELEPHONE MODEMS ====							
	-- NONE --						
500 =========== TIP TERMINALS ====							
	-- NONE --						
600 ========== HOST INTERFACE ====							
	CDC 7600 HDWR. INT.		12-72	-----	$	12,000	INVESTMENT
	CDC 7600 SFTWR.MOD.		12-72	-----	$	20,000	NON-RECUR.
700 ============ HOST MACHINE ====							
	-- NONE --						
800 ======== LOCAL FACILITIES ====							
	LOCAL IMP MAINT.		12-72	-----	$	420	/MONTH
900 ======== LOCAL MANAGEMENT ====							
	-- NONE --						

SITE INVENTORY SEPTEMBER 26 , 1973

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO UCLA	1	2-73	-----	$	643	/MONTH
LINE TO RAND	7	2-73	-----	$	860	/MONTH

150 ================= MODEMS ====

MODEM TO UCLA		2-73	-----	$	425	/MONTH
MODEM TO RAND		2-73	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		2-73	-----	$	10,000	INVESTMENT

200 =================== IMPS ====

IMP		2-73	-----	$	45,000	INVESTMENT

300 =================== TIPS ====

-- NONE --

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

B6700 HDWR. INT.		2-73	-----	$	12,000	INVESTMENT
B6700 SFTWR. MOD.		2-73	-----	$	20,000	NON-RECUR.

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL IMP MAINT.		2-73	-----	$	420	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

Site Inventory September 26 , 1973

Equipment Class

Line	Connect Site No.	Date Added	Date Removed	Cost	Type
100 ============ LEASED LINES ====					
-- NONE --					
150 ================== MODEMS ====					
Modem to AMES		12-72	-----	$ 425	/MONTH
180 ======== MODEM INTERFACES ====					
1 Modem interface		12-72	-----	$ 5,000	INVESTMENT
200 ==================== IMPS ====					
-- NONE --					
300 ==================== TIPS ====					
TIP		12-72	-----	$ 92,000	INVESTMENT
400 === LOCAL TELEPHONE LINES ====					
-- NONE --					
450 == LOCAL TELEPHONE MODEMS ====					
-- NONE --					
500 =========== TIP TERMINALS ====					
-- NONE --					
600 ========== HOST INTERFACE ====					
-- NONE --					
700 ============ HOST MACHINE ====					
-- NONE --					
800 ======== LOCAL FACILITIES ====					
Local TIP maint.		12-72	-----	$ 585	/MONTH
900 ======== LOCAL MANAGEMENT ====					
-- NONE --					

EQUIPMENT CLASS

100 ============ LEASED LINES ====

LINE	CONNECT SITE NO.	DATE ADDED	DATE REMOVED		COST	TYPE
LINE TO ISI	22	2-73	-----	$	13,424	/MONTH
LINE TO ETAT	20	2-73	-----	$	4,589	/MONTH

150 ================= MODEMS ====

MODEM TO ISI		2-73	-----	$	425	/MONTH
MODEM TO ETAT		2-73	-----	$	425	/MONTH

180 ======== MODEM INTERFACES ====

2 MODEM INTERFACES		2-73	-----	$	10,000	INVESTMENT

200 =================== IMPS ====

-- NONE --

300 =================== TIPS ====

TIP		2-73	-----	$	92,000	INVESTMENT

400 === LOCAL TELEPHONE LINES ====

-- NONE --

450 == LOCAL TELEPHONE MODEMS ====

-- NONE --

500 =========== TIP TERMINALS ====

-- NONE --

600 ========== HOST INTERFACE ====

-- NONE --

700 ============ HOST MACHINE ====

-- NONE --

800 ======== LOCAL FACILITIES ====

LOCAL TIP MAINT.		2-73	-----	$	585	/MONTH

900 ======== LOCAL MANAGEMENT ====

-- NONE --

GENERAL AND DEVELOPMENT FACILITIES

FACILITY	DATE ADDED	DATE REMOVED	COST	TYPE
000 == DEVELOPMENT FACILITIES ====				
NETWORK ANALYSIS CORP. (NAC)	1-70	12-75	$ 10,000	/MONTH
BOLT BERANEK & NEWMAN (BBN)	1-70	1-70	$10,000,000	TOTAL
050 ====== GENERAL FACILITIES =====				
BBN NETWORK CONTROL CENTER	1-70	12-75	$ 50,000	/MONTH
SRI NETWORK INFORMATION CENTER	1-70	12-75	$ 48,000	/MONTH
MITRE	1-72	12-75	$ 10,000	/MONTH
RANGE MEASUREMENTS LAB (RML)	1-72	12-75	$ 5,000	/MONTH
ARPA WASHINGTON	1-70	12-75	$ 8,000	/MONTH
UCLA NETWORK MEASUREMENT CENTER	1-70	12-74	$ 20,000	/MONTH
CABLEDATA	1-73	1-74	$ 10,000	/MONTH
RCA FLORIDA	12-69	12-69	$ 0	/MONTH

Appendix I

FINANCIAL ANALYSIS OF THE ARPANET PROGRAM (RON1 & RON2)

by

RONALD C. CRANE

PREFACE

These programs form the heart of the analysis framework used by Cabledata Associates to estimate the value of the ARPANET at any point in history, under various costing and depreciation schedules and with any combination of elements added and/or removed. They use the same data base files used in Appendix H, ARPANET INVENTORY, by Ronald Crane. The reader should review Appendix H to better understand what is and is not included in the definition of the resources at any site. For example, at the start of this Cabledata Associates project for ARPA, ARPA chose to have the study limited to the network per se: lines, IMPS, TIPS, modems, etc. and would not at this time include host machines and/or other ARPA-owned facilities.

These programs are written in BASIC for the Hewlett-Packard 2000F timesharing system, because access to this fast response system is only $3.00/hour including cpu during the hours when this work was done. However, it appears that these programs have a longer continuing applicability. They could be altered easily to run on an ARPANET computer.

PROGRAMS RON1 & RON2

FUNCTION

These programs will calculate the book value of the network, monthly cost in the requested month, as well as per site values of the previous quantities for the ARPANET. Parts of the network may be deleted and the cost of the network with and without these parts and the difference of these costs may be obtained. Different costing bases and depreciation rates and periods may be used.

HOW TO USE

Log on the computer system,

type GET-RON1

type RUN

The program will take you from there. It is helpful if the user has at hand the "ARPANET Inventory Listing Program (RONA)", CAWP# 107 (Appendix J) and a logical map of the network.

SPECIAL NOTES

The depreciation rate applies to both the investments and the one-time charges such as lease set-up charges.

The scrap value is applied only to investments. Non-recurring costs (lease set-up charges) all go to zero since they have no scrap value.

Month M is not charged for equipment bought and sold prior to month M. It is assumed that the equipment was sold for its book value at the time the equipment was removed.

Up to 97 sites can be examined, provided they are present in the data base file FDATA and the name file FILE4.

Programs RON1 and RON2 work together to provide the financial analysis. It is separated into two program blocks because the system storage capacity will not allow it to fit under one program name. Any changes in either of the programs involving renumbering must include a change of the other program so that it chains to the proper place in the program being changed.

VARIABLES USED

A	Date equipment added
A(1)	Marginal Cost option flag (input by user of program)
A(2)	Value of "$ per month per site" in first run
A(3)	Value of "$ per month total" in first run
A(4)	Value of "Total investment to date" in first run
A(5)	Value of "Total depreciation to date" in first run
A(6)	Value of "Book value of the network" in first run
A(7)	Value of "Total investment in month M" in first run
A(8)	Value of "Average investment per site in month M" in first run
A(9)	Value of "New rent added in month M"
B	Date equipment removed
B(1)-B(98)	Flags denoting that all the leased lines at a node are to be deleted
B(99)	The number of nodes with all lines deleted
C	Cost type (1=monthly, 2=investment, 3=non-recurring)
D	Cost
D(1)	Day number
D(2)	Year number
D(3)	Leap year option
E	Equipment number
F$	Equipment name
G	Site number
H$	Site name
I	Connected Site number (used for leased lines, otherwise = 0)
K	Type of cost, (1=short term marginal, 2=long term marginal, 3=fully allocated)
L	Margin constant (horizontal position of output on page)
L(1)	Depreciation rate specifier (1=straight line, 2=sum of the digits
L(2)	Depreciation period (months)
L(3)	Scrap value (fraction of purchase price)
L(4)	Dummy used to make non-recurring costs have 0 scrap value

L(5)	Number of applicable depreciation months	
L$(20)	Dummy character variable used for entering answers to input routine	
M	Month number of evaluation	
M(1)	Internal dummy for month of evaluation calculation	
M(2)	Year of month M	
M(3)	Month # of month M	
M(4)	Beginning year (1970)	
M(5)	Beginning month # in beginning year (0)	
M$(15)	Character variable for month names	
N	Cumulative investment through month M	
N(1)-N(97)	Flags denoting that a node is to be deleted if the flag = 1	
N(98)	The number of nodes to be deleted	
N(99)	Node number corresponding to general & development facilities	
O	Cumulative rent in month M	
O1	Output variable for number subroutine	
P	Cumulative depreciation of purchase	
Q	Investment in month M	
Q1	Instruction request flag, (Yes=1, No=0)	
R(1)-R(99)	Flags indicating that the site was used in the calculations	
R1	Flag variable - if equal to 1, it denotes a change in the leased line rates	
R2	Rate for 0 - 250 miles	
R3	Rate for 251 - 500 miles	Leased Line rate changes (otherwise assumed to be a flat rate of $5.83 per mile per month.)
R4	Rate for 501 - 1000 miles	
R5	Rate for 1001 - 1500 miles	
R6	Rate for greater than 1500 miles	
R7	Dummy for leased line calculation section	
R8	Dummy for leased line calculation section	
S	Number of sites used in the calculations	
S(1)-S(99)	Flags indicating that the site was used in the calculations	
T	Total of one-time, non-recurring costs (lease set-up costs)	
U	New non-recurring or lease set-up (LSU) costs in month M	

V New rent in month M

W Amortization of investments and non-recurring costs applicable to month M

Y Dummy variable used for DO-LOOPS

Z Dummy variable used for input routines

FILES USED IN PON1

File #1 FDATA (Contains the data base. It is created by another program FILMAK from the primary data base programs DATA-1 and DATA-2.)

File #2 FILE4 (Contains a list of the names of the nodes in order. It is created by the program FILER with user interaction.)

CDM1

```
10   COM A,A[9],B,B[99],C,D,[illegible]
20   COM M,M[5],N,N[99],[illegible]
30   COM R1,R2,R3,R4,R5,R6,R7,R8
40   COM M$[15]
42   REM            THERE ARE 3 CHAIN STATEMENTS IN THIS PROGRAM.
45   REM            THEY ARE STATEMENT NUMBERS 1490, 1780, AND 4150.
50   L=15
60   FILES FDATA,FILE4
70   IF  END #1 THEN 1210
80   FOR Y=1 TO 99
90   N[Y]=B[Y]=I[Y]=P[Y]=0
100  NEXT Y
110  REM ******************* END OF DATA SECTION ******************************

120  PRINT " DO YOU WANT INSTRUCTIONS ( Y / N ) ";
130  INPUT L$
140  IF L$[1]="Y" THEN 200
150  IF L$[1]="Y" THEN 200
160  IF L$[1]="N" THEN 220
170  IF L$[1]="N" THEN 220
180  PRINT " INPUT MUST BEGIN WITH Y OR N.  PLEASE RETYPE.";
190  GOTO 130
200  Q1=1
210  GOTO 230
220  Q1=0
230  GOTO 320
240  REM ********************************************************************
250  REM            THIS IS THE POINT WHERE THE CALCULATIONS START
260  REM            IN THE PROGRAM.
270  READ #1,1
280  N=O=P=Q=R=S=T=U=V=W=X=Y=Z=0
290  REM  THIS IS THE BEGINNING OF THE CALCULATION LOOP
300  IF TYP(1)=3 THEN 1210
310  READ #1;A,B,C,D,E,F$,G,H$,I
320  IF A[1]=1 THEN 410
330  IF N[G]=1 THEN 1190
340  IF E<150 AND E >= 100 THEN 360
350  GOTO 410
360  IF B[G]=1 THEN 1190
370  IF B[I]=1 THEN 1190
380  IF R1=1 THEN 400
390  GOTO 410
400  GOSUB 4880
410  IF E<100 THEN 430
420  GOTO 440
430  IF K<3 THEN 1190
440  REM          IS THE ITEM IN THE FUTURE WITH RESPECT TO MONTH M?
450  IF A>M THEN 1190
460  IF C=1 THEN 520
470  IF C=2 THEN 520
480  IF C=3 THEN 520
```

```
490  PRINT "THERE IS GARBAGE IN THE INPUT DATA. C = 1,2,OR 3."
500  PRINT  USING 510;A,B,C,D,E,F$,G,H$,I
510  IMAGE 3D,X3D,XD,X2D,X3D,X25A,X3D,X12A,X2D
520  REM  ************************ RENT CALCULATIONS ******************************
530  REM     U = ALL RENT                     V = NEW RENT IN MONTH M
540  REM        BOTH OF ABOVE ARE CUMULATIVE OVER ALL ELEMENTS SEARCHED
550  IF C=1 THEN 570
560  GOTO 650
570  IF M>B THEN 1180
580  U=U+D
590  IF A=M THEN 610
600  GOTO 1160
610  V=V+D
620  REM  ********************** INVESTMENT CALCULATIONS **********************
630  REM            N = ALL INVESTMENT        Q = NEW INVESTMENT IN MONTH M
640  REM        BOTH OF ABOVE ARE CUMULATIVE OVER ALL ELEMENTS SEARCHED
650  IF C=2 THEN 670
660  GOTO 750
670  N=N+D
680  IF A=M THEN 700
690  GOTO 750
700  Q=Q+D
710  REM  **************** ONE TIME NON RECOVERABLE COSTS ****************
720  REM                          LEASE SET UP COSTS      (LSU)
730  REM               T = ALL LSU              U = NEW LSU IN MONTH M
740  REM       BOTH OF THE ABOVE ARE CUMULATIVE OVER ALL ELEMENTS SEARCHED
750  IF C=3 THEN 770
760  GOTO 820
770  T=T+D
780  IF A=M THEN 800
790  GOTO 820
800  U=U+D
810  REM********************** MONTHLY AMORTIZATION ****************************

820  REM          W = CUMULATIVE CHARGES APPLICABLE TO MONTH M
830  REM            L(1) = DEPRECIATION RATE SPECIFIER
840  REM                   1-STRAIGHT LINE
850  REM                   2-SUM OF THE DIGITS
860  REM            L(2) = DEPRECIATION PERIOD (TIME TO SCRAP VALUE)
870  REM            L(3) = SCRAP VALUE  (FRACTION OF PURCHASE PRICE)
880  REM            L(4) = DUMMY USED TO MAKE NON-RECURRING COSTS HAVE
890  REM                    ZERO SCRAP VALUE.
900  REM            L(5) = NUMBER OF APPLICABLE DEPRECIATION MONTHS
910  REM             P     = TOTAL DEPRECIATION OF ALL INVESTMENTS TO MONTH M
920  IF C=3 THEN 940
930  IF B<M THEN 1060
940  L[5]=M-A
950  IF L[5]>L[2] THEN 1070
960  IF F=1 THEN 1070
970  IF C=2 THEN 1000
980  L[4]=0
990  GOTO 1010
1000  L[4]=L[3]
```

```
1010  IF L[1]=2 THEN 1040
1020  P=P+D*(1-L[4])/L[2]
1030  GOTO 1050
1040  P=P+D*2*(1-L[4])*(L[2]-L[5])/((L[2]+1)*L[2])
1050  GOTO 1070
1060  L[5]=B-A
1070  IF C=3 THEN 1160
1080  IF L[5]>L[2] THEN 1140
1090  IF L[1]=2 THEN 1120
1100  P=P+D*L[5]*(1-L[3])/L[2]
1110  GOTO 1160
1120  P=P+D*(1-L[3])*(1-(L[2]-L[5]+1)*(L[2]-L[5])/((L[2]+1)*L[2]))
1130  GOTO 1160
1140  P=P+(1-L[3])*D
1150  REM **************************** SITES USED IN THE CALCULATIONS **********
1160  P[G]=1
1170  REM  ************************SITES EXAMINED ********************************
1180  S[G]=1
1190  GOTO 290
1200  REM  ********************* MONTH CALCULATION ****************************
1210  REM              M(4) = BEGINNING YEAR
1220  REM              M(5) = MONTH 0  (ONE MONTH BEFORE BEGINNING)
1230  M[4]=1970
1240  M[5]=0
1250  M[1]=M+M[5]
1260  REM           M(2) IS THE YEAR OF MONTH M
1270  M[2]=INT(M[1]/12)+M[4]
1280  REM           M(3) IS THE MONTH IN YEAR M(2) OF MONTH M
1290  M[3]=M[1]-12*(INT(M[1]/12))
1300  IF M[3]=0 THEN 1320
1310  GOTO 1340
1320  M[3]=12
1330  M[2]=M[2]-1
1340  REM ---------------- NUMBER OF SITES CALCULATION ------------ ----------
1350  S=0
1360  FOR Y=1 TO 99
1370  S=S[Y]+S
1380  NEXT Y
1390  REM  ******************* END OF CALCULATION SECTION **********************
1400  REM *************** OUTPUT SECTION *********************************
1410  PRINT LIN(3);
1420  IF A[1]=2 THEN 1830
1430  PRINT TAB(L);
1440  PRINT  USING 1450
1450  IMAGE  "=================== CABLEDATA ASSOCIATES =======================

1460  PRINT TAB(L);
1470  PRINT "                    ARPANET COST ANALYSIS MODEL"
1480  PRINT LIN(1);
1485  REM ** ** ** ** ** ** ** ** ** ** ** CHAIN STATEMENT ** ** ** ** ** ** **
1490  CHAIN "RON2",460
1500  PRINT TAB(L);SPA(20);M$;SPA(1);D[1];", ";D[2]
1510  PRINT LIN(1);
1520  READ #1,1
```

```
1530  READ #1;A,B,C,D,E,F$,G,H$,I
1540  PRINT TAB(L);SPA(20);F$
1550  PRINT LIN(1);
1560  PRINT TAB(L);"                          SUMMARY OF INPUTS"
1570  PRINT LIN(1);
1580  PRINT TAB(L);"MONTH OF EVALUATION (M) ---- ";M;" OR ";M[3];"-";M[2]
1590  PRINT TAB(L);"COSTING BASIS -------------- ";
1600  PRINT " ";
1610  IF K=1 THEN 1650
1620  IF K=2 THEN 1670
1630  PRINT "F -- FULLY ALLOCATED"
1640  GOTO 1680
1650  PRINT "S -- SHORT TERM MARGINAL"
1660  GOTO 1680
1670  PRINT "L -- LONG TERM MARGINAL"
1680  PRINT TAB(L);"DEPRECIATION RATE ---------- ";L[2]/12;
1690  IF L[1]=1 THEN 1730
1700  PRINT  USING 1710
1710  IMAGE "YEARS SUM OF THE DIGITS"
1720  GOTO 1750
1730  PRINT  USING 1740
1740  IMAGE "YEARS STRAIGHT LINE"
1750  PRINT TAB(L);"INVESTMENT SCRAP VALUE ----- ";L[3]
1760  IF R1=1 THEN 1780
1770  GOTO 1790
1775  REM ** ** ** ** ** ** ** ** ** **  CHAIN STATEMENT ** *** ** ** ** ** **
1780  CHAIN "RCNS",390
1790  IF A[1]=1 THEN 1810
1800  GOTO 1820
1810  PRINT TAB(L);"MARGINAL COST OPTION INCLUDED"
1820  PRINT LIN(1);
1830  PRINT TAB(L);
1840  PRINT  USING 1920
1850  IF A[1]=3 THEN 1870
1860  GOTO 1920
1870  PRINT LIN(2);
1880  PRINT TAB(L);
1890  PRINT  USING 1910
1900  PRINT LIN(1);
1910  IMAGE X,"**** MARGINAL COST OPTION - COMPARISON OF TWO PREVIOUS COSTS **
1920  IMAGE             "======================== OUTPUTS ===================
1930  IF A[1]=1 THEN 1960
1940  IF A[1]=2 THEN 2000
1950  GOTO 2050
1960  PRINT TAB(L);
1970  PRINT  USING 2030
1980  PRINT LIN(1);
1990  GOTO 2050
2000  PRINT TAB(L);
2010  PRINT  USING 2040
2020  PRINT LIN(1);
2030  IMAGE "**** ALL ITEMS ARE INCLUDED IN THIS OUTPUT ****"
2040  IMAGE "**** DELETED ITEMS ARE NOT INCLUDED IN THIS OUTPUT ****"
```

```
2050  IF O>0 THEN 2090
2060  PRINT TAB(L);"0 NODES WERE USED IN THE CALCULATIONS. CHECK "
2070  PRINT TAB(L);"DATE OF EVALUATION AND/OR DELETION OPTIONS."
2080  GOTO 5150
2090  PRINT TAB(L);"$ PER MONTH PER SITE ---------------------- ";
2100  IF A[1]=3 THEN 2130
2110  O1=(O+W)/2
2120  GOTO 2140
2130  O1=A[2]-(O+W)/2
2140  GOSUB 3050
2150  PRINT TAB(L);"$ PER MONTH TOTAL ------------------------- ";
2160  IF A[1]=3 THEN 2190
2170  O1=O+W
2180  GOTO 2200
2190  O1=A[3]-O-W
2200  GOSUB 3050
2210  PRINT TAB(L);"TOTAL INVESTMENT TO DATE ------------------ ";
2220  IF A[1]=3 THEN 2250
2230  O1=N
2240  GOTO 2260
2250  O1=A[4]-N
2260  GOSUB 3050
2270  PRINT TAB(L);"TOTAL DEPRECIATION TO DATE ---------------- ";
2280  IF A[1]=3 THEN 2310
2290  O1=P
2300  GOTO 2320
2310  O1=A[5]-P
2320  GOSUB 3050
2330  PRINT TAB(L);"BOOK VALUE OF THE NETWORK ----------------- ";
2340  IF A[1]=3 THEN 2370
2350  O1=N-P
2360  GOTO 2380
2370  O1=A[6]-(N-P)
2380  GOSUB 3050
2390  PRINT TAB(L);"TOTAL INVESTMENT IN MONTH M --------------- ";
2400  IF A[1]=3 THEN 2430
2410  O1=Q
2420  GOTO 2440
2430  O1=A[7]-Q
2440  GOSUB 3050
2450  PRINT TAB(L);"AVERAGE INVESTMENT PER SITE IN MONTH M ---- ";
2460  IF A[1]=3 THEN 2490
2470  O1=Q/S
2480  GOTO 2500
2490  O1=A[8]-Q/S
2500  GOSUB 3050
2510  PRINT TAB(L);"NEW RENT ADDED IN MONTH M ----------------- ";
2520  IF A[1]=3 THEN 2550
2530  O1=V
2540  GOTO 2560
2550  O1=A[9]-V
2560  GOSUB 3050
2570  IF A[1]=1 THEN 2590
```

```
2580  GOTO 2670
2590  A[2]=(O+W)/2
2600  A[3]=O+W
2610  A[4]=N
2620  A[5]=P
2630  A[6]=N-P
2640  A[7]=Q
2650  A[8]=O/3
2660  A[9]=V
2670  IF A[1]=1 THEN 2700
2680  IF A[1]=2 THEN 2720
2690  GOTO 2740
2700  A[1]=2
2710  GOTO 270
2720  A[1]=3
2730  GOTO 1850
2740  REM --------------- SITES EXAMINED OUTPUT SECTION -----------------
2750  REM               L - MARGIN CONSTANT
2760  REM        B(--) - DELETED LINES
2770  REM        N(--) - DELETED NODES
2780  REM        R(--) - EXAMINED NODES
2790  REM        S(--) - NODES USED IN THE CALCULATIONS
2800  PRINT LIN(2);
2810  PRINT TAB(L+6);"****** SITE STATUS IN CALCULATIONS ******"
2820  PRINT LIN(1);
2830  PRINT TAB(L+15);" SITE NAME        NO. USED  DELETIONS"
2840  READ #2,1
2850  FOR Y=1 TO 60
2860  IF  END #2 THEN 3020
2870  READ #2;L$
2880  IF L$[1,3]="END" THEN 3020
2890  IF R[Y]=1 THEN 2910
2900  GOTO 3020
2910  PRINT TAB(L+15);L$;TAB(L+30);(Y);TAB(L+35);
2920  IF S[Y]=1 THEN 2940
2930  GOTO 2950
2940  PRINT TAB(L+35);"*";
2950  IF N[Y]=1 THEN 2970
2960  GOTO 2980
2970  PRINT TAB(L+43);"N";
2980  IF B[Y]=1 THEN 3000
2990  GOTO 3010
3000  PRINT TAB(L+49);"L";
3010  PRINT ""
3020  NEXT Y
3030  REM ------------------- END OF SITES EXAMINED OUTPUT SECTION ---------
3040  GOTO 3180
3050  REM --------------- OUTPUT NUMBER SUBROUTINE -----------------------
3060  IMAGE #,"$",DD,DDD,DDD
3070  PRINT  USING 3060;O1
3080  IF O1<1000 THEN 3160
3090  IF O1<1.E+06 THEN 3140
3100  IMAGE ""
3110  PRINT  USING 3100
```

```
3120  GOTO 3170
3130  IMAGE ""
3140  PRINT USING 3130
3150  GOTO 3170
3160  PRINT ""
3170  RETURN
3180  REM -------------- END OF OUTPUT NUMBER SUBROUTINE -----------------
3190  GOTO 4570
3200  IF O1=0 THEN 3490
3210  PRINT "***************** CHILEDNIA ASSOCIATES ***************************

3220  PRINT "-------------- ARPANET COST ANALYSIS MODEL ----------------------

3230  PRINT LIN(2)
3240  PRINT "      THIS PROGRAM WILL CALCULATE THE $ PER MONTH FOR THE NETWORK"
3250  PRINT "AS A WHOLE AND PER SITE FOR THE NUMBER OF SITES EXAMINED.  THE "
3260  PRINT "OUTPUTS ARE BASED ON THE STORED INFORMATION ABOUT THE NETWORK,"
3270  PRINT "AND A SELECTED DEPRECIATION RATE AND COSTING BASIS."
3280  PRINT "      A NODE MAY BE DELETED BY ANSWERING YES ON THE DELETION "
3290  PRINT "REQUEST FROM THE PROGRAM.  LEASED LINE COSTS CAN ALSO BE DELETED"
3300  PRINT "FOR THAT NODE IF THE LINES WOULD NOT PASS THROUGH THE NODE FOR"
3310  PRINT "A DIRECT CONNECTION OTHERWISE.  MODEMS FOR THAT NODE WILL BE "
3320  PRINT "DELETED IN EITHER DELETION OPTION. "
3330  PRINT "      MARGINAL COST INFORMATION CONCERNING THE ADDITIONAL COST"
3340  PRINT "PER NODE AND TO THE NET AS A WHOLE CAN BE OBTAINED BY GIVING AN"
3350  PRINT "AFFIRMATIVE ANSWER TO THE MARGINAL COST OPTION.  IN CALCULATING"
3360  PRINT "THE MARGINAL COST OF A NODE, OR NODES, THE PROGRAM FIRST "
3370  PRINT "DETERMINES WHAT THE NETWORK COSTS ARE WITH THE NODES INCLUDED"
3380  PRINT "PRINTS THE RESULTS, DOES THE COSTS WITH THE NODES LEFT OUT, "
3390  PRINT "PRINTS THE RESULTS, AND THEN SHOWS THE DIFFERENCE BETWEEN THE "
3400  PRINT "TWO CALCULATIONS AS THE MARGINAL COST OF THE NODES SELECTED "
3410  PRINT "IN THE DELETION OPTIONS. "
3420  PRINT LIN(2)
3430  PRINT "      DEPRECIATION RATE, COSTING BASIS, AND MONTH OF EVALUATION"
3440  PRINT "ARE STANDARD WITH ALL OF THE OPTIONS.  THEY MAKE UP THE "
3450  PRINT "FRAMEWORK IN WHICH THE VARIOUS OPTIONS ARE CALCULATED. "
3460  PRINT "      THERE ARE TWO TYPES OF DEPRECIATION RATE AVAILABLE."
3470  PRINT "                      S - STRAIGHT LINE"
3480  PRINT "                      D - SUM OF THE DIGITS"
3490  PRINT "        DEPRECIATION RATE ( S OR D ) ";
3500  INPUT L$
3510  IF L$[1]="d" THEN 3570
3520  IF L$[1]="D" THEN 3570
3530  IF L$[1]="s" THEN 3590
3540  IF L$[1]="S" THEN 3590
3550  PRINT "       INPUT MUST BEGIN WITH D OR S,  RETYPE.";
3560  GOTO 3500
3570  L[1]=2
3580  GOTO 3600
3590  L[1]=1
3600  IF O1=0 THEN 3640
3610  PRINT "       THE DEPRECIATION PERIOD IS THE TIME AFTER WHICH THE"
3620  PRINT "   INVESTMENT HAS DEPRECIATED TO ITS SCRAP VALUE.  SPECIFY "
3630  PRINT "   THE DEPRECIATION PERIOD IN YEARS."
```

```
3640  PRINT "       DEPRECIATION PERIOD ( YEARS ) ";
3650  INPUT L[2]
3660  L[2]=12*L[2]
3670  IF O1=0 THEN 3720
3680  PRINT "      THE SCRAP VALUE OF AN INVESTMENT IS VALUE TO WHICH IT "
3690  PRINT "   DEPRECIATES TO BY THE END OF THE DEPRECIATION PERIOD.  IT"
3700  PRINT "   RETAINS THIS VALUE FOR EVER AFTER.  THE SCRAP VALUE "
3710  PRINT "   IS A FRACTION OF THE ORIGINAL PURCHASE PRICE."
3720  PRINT "    SCRAP VALUE  (DECIMAL FRACTION) ";
3730  INPUT L[3]
3740  IF O1=0 THEN 3840
3750  PRINT LIN(1)
3760  PRINT "     THERE ARE THREE (3) AVAILABLE TYPES OF COSTING BASIS ."
3770  PRINT "      S  - SHORT TERM MARGINAL COST  INCLUDES ONLY MONTHLY"
3780  PRINT "             RENTAL COSTS.  DEPRECIATION AND DEVELOPMENT COSTS"
3790  PRINT "             ARE NOT INCLUDED.)"
3800  PRINT "      L  - LONG TERM MARGINAL COST  (ONLY DEVELOPMENT COSTS "
3810  PRINT "             ARE NEGLECTED.)"
3820  PRINT "      F  - FULLY ALLOCATED COSTS  (ALL COSTS ARE INCLUDED)"
3830  PRINT LIN(1)
3840  PRINT "     COSTING BASIS  ( S , L , OR F ) ";
3850  INPUT L$
3860  IF L$[1]="s" THEN 3940
3870  IF L$[1]="S" THEN 3940
3880  IF L$[1]="l" THEN 3960
3890  IF L$[1]="L" THEN 3960
3900  IF L$[1]="f" THEN 3980
3910  IF L$[1]="F" THEN 3980
3920  PRINT "  INPUT MUST BEGIN WITH S , L , OR F . PLEASE RETYPE."
3930  GOTO 3850
3940  K=1
3950  GOTO 3990
3960  K=2
3970  GOTO 3990
3980  K=3
3990  IF O1=0 THEN 4030
4000  PRINT LIN(1)
4010  PRINT "      PLEASE TYPE IN THE NUMBER OF THE MONTH IN WHICH THE NETWORK"
4020  PRINT "IS TO BE EVALUATED ON THE FOLLOWING LINE. (MONTH 1 = 1-1970 )"
4030  PRINT "                          MONTH NUMBER = ";
4040  INPUT M
4050  IF O1=0 THEN 4130
4060  PRINT LIN(2)
4070  PRINT "----------  NODE DELETION OPTION  ---------------------"
4080  PRINT LIN(1)
4090  PRINT "    IF YOU WANT TO HAVE A NODE OR NODES DELETED, ENTER THE "
4100  PRINT "NUMBER OF NODES TO BE DELETED FIRST ( 0 IF NONE ARE TO BE "
4110  PRINT "DELETED), AND THEN EACH OF THE NODE NUMBERS AS PROMPTED BY "
4120  PRINT "YOUR TERMINAL."
4130  PRINT "HOW MANY NODES ARE TO BE DELETED";
4140  INPUT N[95]
4150  IF N[95]=0 THEN 4370
4160  FOR Y=1 TO N[95]
```

```
4170  REM  This loop sets a flag used in the calculation section of the
4180  REM  program to determine whether an item should be used for
4190  REM  the calculations.
4200  PRINT "The ";
4210  PRINT  USING 4220;Y
4220  IMAGE #, DD
4230  IF Y=1 OR Y=21 OR Y=31 THEN 4280
4240  IF Y=2 OR Y=22 OR Y=32 THEN 4300
4250  IF Y=3 OR Y=23 OR Y=33 OR Y=43 THEN 4320
4260  PRINT "th ";
4270  GOTO 4330
4280  PRINT "st ";
4290  GOTO 4330
4300  PRINT "nd ";
4310  GOTO 4330
4320  PRINT "rd ";
4330  PRINT "Node to be deleted is";
4340  INPUT Z
4350  N[Z]=1
4360  NEXT Y
4370  IF Q1=0 THEN 4440
4380  PRINT LIN(1)
4390  PRINT "---------- Leased Line Deletion Option -----------------------"
4400  PRINT "       This option allows you to remove all the leased lines that"
4410  PRINT "are connected to a node.  This is useful for deleted nodes  "
4420  PRINT "whose lines lines would not be connected straight through if"
4430  PRINT "the node were not there.  "
4440  PRINT "How many nodes are there with all the lines deleted";
4450  INPUT B[99]
4460  IF B[99]=0 THEN 4680
4470  REM  This loop sets a flag used in the calculation section of the
4480  REM  program to determine whether an item should be used for
4490  REM  the calculations.
4500  FOR Y=1 TO B[99]
4510  PRINT "The ";
4520  PRINT  USING 4530;Y
4530  IMAGE #,DD
4540  IF Y=1 OR Y=21 OR Y=31 OR Y=41 OR Y=51 THEN 4590
4550  IF Y=2 OR Y=22 OR Y=32 OR Y=42 OR Y=52 THEN 4610
4560  IF Y=3 OR Y=23 OR Y=33 OR Y=43 OR Y=53 THEN 4630
4570  PRINT "th ";
4580  GOTO 4640
4590  PRINT "st ";
4600  GOTO 4640
4610  PRINT "nd ";
4620  GOTO 4640
4630  PRINT "rd ";
4640  PRINT "Node to have all lines deleted is";
4650  INPUT Z
4660  B[Z]=1
4670  NEXT Y
4680  IF N[98]>0 THEN 4720
4690  IF B[99]>0 THEN 4720
4700  A[1]=0
```

```
4710  GOTO 4850
4720  IF O1=0 THEN 4740
4730  PRINT "      Do you want the MARGINAL COST option as described above? "
4740  PRINT "  Marginal Cost Option ( Y/N ) ";
4750  INPUT L$
4760  IF L$[1]="y" THEN 4840
4770  IF L$[1]="Y" THEN 4840
4780  IF L$[1]="N" THEN 4820
4790  IF L$[1]="n" THEN 4820
4800  PRINT "  Input must begin with a Y or N. Please Retype.  "
4810  GOTO 4750
4820  A[1]=0
4830  GOTO 4850
4840  A[1]=1
4845  REM ** ** ** ** ** ** *** ** ** ** CHAIN STATEMENT ** ** ** ** ** ** ** *

4850  CHAIN "RONE",50
4860  GOTO 240
4870  GOTO 5150
4880  REM ****************** Leased Line Calculation Section *******************
4890  REM determine the number of miles in the link by dividing the cost
4900  REM by the flat rate of $ 5.83 per mile per month.
4910  R7=I/5.83
4920  IF R7-250>0 THEN 4950
4930  R8=R7*R2
4940  GOTO 5130
4950  R7=R7-250
4960  R8=250*R2
4970  IF R7-250>0 THEN 5000
4980  R8=R8+R7*R3
4990  GOTO 5130
5000  R7=R7-250
5010  R8=R8+250*R3
5020  IF R7-500>0 THEN 5050
5030  R8=R8+R7*R4
5040  GOTO 5130
5050  R7=R7-500
5060  R8=R8+500*R4
5070  IF R7-500>0 THEN 5100
5080  R8=R8+R7*R5
5090  GOTO 5130
5100  R7=R7-500
5110  R8=R8+(500*R5)+(R7*R6)
5120  R=R8
5130  RETURN
5140  REM *************** End of Leased Line calculation section ************
5150  END
```

RON3

```
10  COM A,A[?],B,B[??],C,D,D[?],E,F[illegible],G,H[illegible],I,K,L,L[illegible],L[5]
20  COM M,M[5],N,N[??],O,O1,P,Q,Q1,R[??],[illegible][??],T,U,V,W,X,Z
30  COM R1,R2,R3,R4,R5,R6,R7,R8
40  COM M$[15]
45  REM           There are 3 chain statements in this program.
46  REM           They are statement numbers 330, 450 , and 1010.
50  REM *************** Leased Line Modification input routine ***************
60  IF O1=0 THEN 140
70  PRINT "       The leased lines used for the network vary in price"
80  PRINT "with time and the quantity leased.  Line charges are based"
90  PRINT "on point to point airline mileage.  Pricing is on a sliding"
100  PRINT "scale such that the per mile per month charge goes down as"
110  PRINT "the distance goes up for a given circuit.  Unless otherwise"
120  PRINT "requested, a flat rate of 15.83 per mile per month "
130  PRINT "independent of distance will be used."
140  PRINT "Do you want to specify new rates ";
150  INPUT L$
160  IF L$[1]="y" THEN 200
170  IF L$[1]="Y" THEN 200
180  R1=0
190  GOTO 330
200  R1=1
210  PRINT "   Specify the leased  line costs in $ per mile per month:"
220  PRINT "    0 -  250 miles   $/mile-month = ";
230  INPUT R2
240  PRINT "  251 -  500 miles   $/mile-month = ";
250  INPUT R3
260  PRINT "  501 - 1000 miles   $/mile-month = ";
270  INPUT R4
280  PRINT " 1001 - 1500 miles   $/mile-month = ";
290  INPUT R5
300  PRINT "   over 1500 miles   $/mile-month = ";
310  INPUT R6
320  PRINT LIN(1);
325  REM ** ** ** ** ** ** ** ** ** ** ** CHAIN STATEMENT ** ** ** ** ** **
330  CHAIN "RON1",4860
340  REM ************* Leased Line Output Subroutine ************************
350  PRINT TAB(L+5);"The cost of leased lines in $ per month per mile"
360  PRINT TAB(L+5);"is as follows:"
370  PRINT LIN(1);
380  PRINT TAB(L);
390  PRINT  USING 400
400  IMAGE "Miles      0-250     251-500   501-1000  1001-1500  >1500"
410  PRINT TAB(L+10);
420  PRINT  USING 430;R2,TAB(L+20),R3,TAB(L+30),R4,TAB(L+40),R5,TAB(L+50),R6
430  IMAGE "$",DD.DDxxxx
440  PRINT LIN(1);
445  REM ** ** ** ** ** ** ** ** ** ** ** CHAIN STATEMENT ** ** ** ** ** ** **
450  CHAIN "RON1",1790
460  REM +++++++++++++++++++ Today's Date +++++++++++++++++++++++++++++++++
470  IF TIM(3)/4=INT(TIM(3)/4) THEN 490
480  GOTO 510
```

```
490  D[3]=1
500  GOTO 520
510  D[3]=0
520  D[2]=TIM(3)+1900
530  D[1]=TIM(2)
540  IF D[1] <= 31 THEN 690
550  D[1]=D[1]+D[3]
560  IF D[1] <= 59 THEN 710
570  IF D[1] <= 90 THEN 740
580  IF D[1] <= 120 THEN 770
590  IF D[1] <= 151 THEN 800
600  IF D[1] <= 181 THEN 830
610  IF D[1] <= 212 THEN 860
620  IF D[1] <= 243 THEN 890
630  IF D[1] <= 273 THEN 920
640  IF D[1] <= 304 THEN 950
650  IF D[1] <= 334 THEN 980
660  D[1]=D[1]-334
670  M$="December"
680  GOTO 1000
690  M$="January"
700  GOTO 1000
710  D[1]=D[1]-31
720  M$="February"
730  GOTO 1000
740  D[1]=D[1]-59
750  M$="March"
760  GOTO 1000
770  D[1]=D[1]-90
780  M$="April'
790  GOTO 1000
800  D[1]=D[1]-59
810  M$="May"
820  GOTO 1000
830  D[1]=D[1]-151
840  M$="June"
850  GOTO 1000
860  D[1]=D[1]-181
870  M$="July'
880  GOTO 1000
890  D[1]=D[1]-212
900  M$="August"
910  GOTO 1000
920  D[1]=D[1]-243
930  M$="September"
940  GOTO 1000
950  D[1]=D[1]-273
960  M$='October"
970  GOTO 1000
980  D[1]=D[1]-304
990  M$="November"
1000  REM*************** END OF Today's Date SECTION *************************
1005  REM ** ** ** ** ** ** ** ** ** **  CHAIN STATEMENT ** ** ** ** ** ** **
1010  CHAIN "ron1",1500
1020  END
```

Appendix J

USING THE PROGRAM RON I FOR COST AND VALUE DETERMINATION

by

RONALD C. CRANE

PREFACE

This appendix shows some preliminary examples of the use of the RON1 and RON2 computer programs described in Appendix I, FINANCIAL ANALYSIS OF THE ARPANET PROGRAM (RON1 & RON2), by Ronald C. Crane.

This program, written in BASIC for the HP200F, is self-documenting. The computer output itself is used in this (Appendix J) paper. This program run, together with some simple outputs, forms a sufficient description of its general use.

The program has been designed so that different parameters, such as different communications lines tariffs, may be used and the differential results compared. The output is arranged in narrow column form to permit many different runs to be made and compared to one another by simply using scissors and glue to produce an effective infinite width printout.

The detailed listing of facilities considered in each run is described in Appendix H, ARPANET INVENTORY..

This program has been made operative only recently, so it is entirely conveivable that there yet may be undetected bugs. Thus, this program is still subject to expected reviews and changes.

The examples tested here are for

1. 10/73, *Fully allocated, 5-year straight line depreciation, scrap value = 10% (With one node deleted for test.)
2. 6/71, Long term marginal, 5-year straight line depreciation, scrap value = 10%
3. 6/71, Fully allocated, 5-year straight line depreciation, scrap value = 10%
4. 10/73, *Fully allocated, 5-year straight line depreciation, scrap value = 10%
5. 10/73, * Long term marginal, 5-year straight line depreciation, scrap value = 10%
6. 10/73, *Fully allocated, 5-year sum of the digits, scrap value = 0%

*As we have made no additions to our present data base of the ARPANET for the month of October 1973, this month will show a zero for new additions.

RUN1

DO YOU WANT INSTRUCTIONS (Y / N) ? Y

```
****************** CABLEDATA ASSOCIATES ****************************
-------------- ARPANET COST ANALYSIS MODEL ------------------------
```

THIS PROGRAM WILL CALCULATE THE $ PER MONTH FOR THE NETWORK AS A WHOLE AND PER SITE FOR THE NUMBER OF SITES EXAMINED. THE OUTPUTS ARE BASED ON THE STORED INFORMATION ABOUT THE NETWORK, AND A SELECTED DEPRECIATION RATE AND COSTING BASIS.

A NODE MAY BE DELETED BY ANSWERING YES ON THE DELETION REQUEST FROM THE PROGRAM. LEASED LINE COSTS CAN ALSO BE DELETED FOR THAT NODE IF THE LINES WOULD NOT PASS THROUGH THE NODE FOR A DIRECT CONNECTION OTHERWISE. MODEMS FOR THAT NODE WILL BE DELETED IN EITHER DELETION OPTION.

MARGINAL COST INFORMATION CONCERNING THE ADDITIONAL COST PER NODE AND TO THE NET AS A WHOLE CAN BE OBTAINED BY GIVING AN AFFIRMATIVE ANSWER TO THE MARGINAL COST OPTION. IN CALCULATING THE MARGINAL COST OF A NODE, OR NODES, THE PROGRAM FIRST DETERMINES WHAT THE NETWORK COSTS ARE WITH THE NODES INCLUDED, PRINTS THE RESULTS, DOES THE COSTS WITH THE NODES LEFT OUT, PRINTS THE RESULTS, AND THEN SHOWS THE DIFFERENCE BETWEEN THE TWO CALCULATIONS AS THE MARGINAL COST OF THE NODES SELECTED IN THE DELETION OPTIONS.

DEPRECIATION RATE, COSTING BASIS, AND MONTH OF EVALUATION ARE STANDARD WITH ALL OF THE OPTIONS. THEY MAKE UP THE FRAMEWORK IN WHICH THE VARIOUS OPTIONS ARE CALCULATED.

THERE ARE TWO TYPES OF DEPRECIATION RATE AVAILABLE.

S - STRAIGHT LINE

D - SUM OF THE DIGITS

DEPRECIATION RATE (S OR D) ? S

THE DEPRECIATION PERIOD IS THE TIME AFTER WHICH THE INVESTMENT HAS DEPRECIATED TO ITS SCRAP VALUE. SPECIFY THE DEPRECIATION PERIOD IN YEARS.

DEPRECIATION PERIOD (YEARS) ? 5

THE SCRAP VALUE OF AN INVESTMENT IS VALUE TO WHICH IT DEPRECIATES TO BY THE END OF THE DEPRECIATION PERIOD. IT RETAINS THIS VALUE FOR EVER AFTER. THE SCRAP VALUE IS A FRACTION OF THE ORIGINAL PURCHASE PRICE.

SCRAP VALUE (DECIMAL FRACTION) ? .1

```
THERE ARE THREE (3) AVAILABLE TYPES OF COSTING BASIS .
 S  - SHORT TERM MARGINAL COST  INCLUDES ONLY MONTHLY
       RENTAL COSTS.  DEPRECIATION AND DEVELOPMENT COSTS
       ARE NOT INCLUDED.)
 L  - LONG TERM MARGINAL COST  (ONLY DEVELOPMENT COSTS
       ARE NEGLECTED.)
 F  - FULLY ALLOCATED COSTS  (ALL COSTS ARE INCLUDED)


COSTING BASIS  ( S , L , OR F ) ?F


     PLEASE TYPE IN THE NUMBER OF THE MONTH IN WHICH THE NETWORK
IS TO BE EVALUATED ON THE FOLLOWING LINE. (MONTH 1 = 1-1979 )
                      MONTH NUMBER = ?24



---------- NODE DELETION OPTION --------------------


     IF YOU WANT TO HAVE A NODE OR NODES DELETED, ENTER THE
NUMBER OF NODES TO BE DELETED FIRST ( 0 IF NONE ARE TO BE
DELETED), AND THEN EACH OF THE NODE NUMBERS AS PROMPTED BY
YOUR TERMINAL.
HOW MANY NODES ARE TO BE DELETED?0


--------- LEASED LINE DELETION OPTION --------------------
     THIS OPTION ALLOWS YOU TO REMOVE ALL THE LEASED LINES THAT
ARE CONNECTED TO A NODE.  THIS IS USEFUL FOR DELETED NODES
WHOSE LINES LINES WOULD NOT BE CONNECTED STRAIGHT THROUGH IF
THE NODE WERE NOT THERE.
HOW MANY NODES ARE THERE WITH ALL THE LINES DELETED?0
```

Example 1

```
RUN
FON1

 DO YOU WANT INSTRUCTIONS ( Y / N ) ?N
      DEPRECIATION RATE ( S OR D ) ?S
     DEPRECIATION PERIOD ( YEARS ) ?5
   SCRAP VALUE  (DECIMAL FRACTION) ?.1
   COSTING BASIS  ( S , L , OR F ) ?F
                  MONTH NUMBER = ?46
HOW MANY NODES ARE TO BE DELETED?1
THE  1ST NODE TO BE DELETED IS?5
HOW MANY NODES ARE THERE WITH ALL THE LINES DELETED?0
  MARGINAL COST OPTION ( Y/N ) ?Y
```

================== CABLEDATA ASSOCIATES ========================

ARPANET COST ANALYSIS MODEL

OCTOBER 11 , 1973

DATA BASE ACCURATE AS OF 6-73

SUMMARY OF INPUTS

MONTH OF EVALUATION (M) ---- 46 OR 10 - 1973
COSTING BASIS -------------- F -- FULLY ALLOCATED
DEPRECIATION RATE ---------- 5 YEAR, STRAIGHT LINE
INVESTMENT SCRAP VALUE ----- .1
MARGINAL COST OPTION INCLUDED

========================= OUTPUTS =====================

**** ALL ITEMS ARE INCLUDED IN THIS OUTPUT ****

$ PER MONTH PER SITE ---------------------	$	12,575
$ PER MONTH TOTAL -------------------------	$	503,257
TOTAL INVESTMENT TO DATE -----------------	$	2,453,000
TOTAL DEPRECIATION TO DATE ---------------	$	1,033,470
BOOK VALUE OF THE NETWORK ----------------	$	2,419,530
TOTAL INVESTMENT IN MONTH M --------------	$	0
AVERAGE INVESTMENT PER SITE IN MONTH M ----	$	0
NEW RENT ADDED IN MONTH M ----------------	$	0

========================= OUTPUTS =====================

**** DELETED ITEMS ARE NOT INCLUDED IN THIS OUTPUT ****

$ PER MONTH PER SITE ---------------------	$	12,461
$ PER MONTH TOTAL -------------------------	$	499,052
TOTAL INVESTMENT TO DATE -----------------	$	2,350,000
TOTAL DEPRECIATION TO DATE ---------------	$	987,120
BOOK VALUE OF THE NETWORK ----------------	$	2,362,880
TOTAL INVESTMENT IN MONTH M --------------	$	0
AVERAGE INVESTMENT PER SITE IN MONTH M ----	$	0
NEW RENT ADDED IN MONTH M ----------------	$	0

**** MARGINAL COST OPTION - COMPARISON OF TWO PREVIOUS COSTS **

$ PER MONTH PER SITE ---------------------	$	114
$ PER MONTH TOTAL -------------------------	$	4,205
TOTAL INVESTMENT TO DATE -----------------	$	103,000
TOTAL DEPRECIATION TO DATE ---------------	$	46,350
BOOK VALUE OF THE NETWORK ----------------	$	56,650
TOTAL INVESTMENT IN MONTH M --------------	$	0
AVERAGE INVESTMENT PER SITE IN MONTH M ----	$	0
NEW RENT ADDED IN MONTH M ----------------	$	0

◆◆◆◆◆◆ SITE STATUS IN CALCULATIONS ◆◆◆◆◆◆

SITE NAME	NO. USED		DELETIONS
UCLA	1	◆	
SRI	2	◆	
UCSB	3	◆	
UTAH	4	◆	
BBN	5	◆	N
MIT	6	◆	
RAND	7	◆	
SDC	8	◆	
HARV	9	◆	
LL	10	◆	
STAN	11	◆	
ILL	12	◆	
CASE	13	◆	
CMU	14	◆	
AMES	15	◆	
AMES	16	◆	
MITR	17	◆	
RADC	18	◆	
NBS	19	◆	
ETAT	20	◆	
TINK	21	◆	
McCL	22	◆	
USC	23	>	
GWC	24	◆	
NOAT	25	◆	
SDAT	26	◆	
BELV	27	◆	
ARPA	28	◆	
ABRD	29	◆	
BBN	30	◆	
CCAT	31	◆	
XROX	32	◆	
FNWC	33	◆	
LBL	34	◆	
UCSD	35	◆	
HAWI	36	◆	
RMLT	37	◆	

Example 2

```
RUN
FON1

 DO YOU WANT INSTRUCTIONS ( Y / N ) ?N
       DEPRECIATION RATE ( S OR D ) ?S
      DEPRECIATION PERIOD ( YEARS ) ?5
    SCRAP VALUE  (DECIMAL FRACTION) ?.1
    COSTING BASIS  ( S , L , OR F ) ?L
                      MONTH NUMBER = ?18
HOW MANY NODES ARE TO BE DELETED?0
HOW MANY NODES ARE THERE WITH ALL THE LINES DELETED?0


  ================== CABLEDATA ASSOCIATES ======================

                  ARPANET COST ANALYSIS MODEL

                      OCTOBER  11   ,  1979

                 DATA BASE ACCURATE AS OF 6-73

                       SUMMARY OF INPUTS

  MONTH OF EVALUATION (M) ----  18     OR  6     - 1971
  COSTING BASIS -------------   L -- LONG TERM MARGINAL
  DEPRECIATION RATE ----------  5     YEAR, STRAIGHT LINE
  INVESTMENT SCRAP VALUE -----  .1

  ========================== OUTPUTS =====================
  $ PER MONTH PER SITE ---------------------- $      3,466
  $ PER MONTH TOTAL ------------------------- $     38,131
  TOTAL INVESTMENT TO DATE ------------------ $    943,000
  TOTAL DEPRECIATION TO DATE ---------------- $     47,640
  BOOK VALUE OF THE NETWORK ----------------- $    895,360
  TOTAL INVESTMENT IN MONTH M --------------- $    199,000
  AVERAGE INVESTMENT PER SITE IN MONTH M ---- $     18,091
  NEW RENT ADDED IN MONTH M ----------------- $      2,082


       ****** SITE STATUS IN CALCULATIONS ******

                 SITE NAME       NO. USED   DELETIONS
                UCLA             1    *
                SRI              2    *
                UCSB             3    *
                UTAH             4    *
                BBN              5    *
                MIT              6    *
                RAND             7    *
                SDC              8    *
                HARV             9    *
                LL               10   *
                MITR             11   *
```

Example 3

```
RUN
PON1

 DO YOU WANT INSTRUCTIONS ( Y , N ) ?N
       DEPRECIATION RATE ( S OR D ) ?S
      DEPRECIATION PERIOD ( YEARS ) ?5
    SCRAP VALUE  (DECIMAL FRACTION) ?.1
    COSTING BASIS  ( S , L , OR F ) ?F
                     MONTH NUMBER = ?19
HOW MANY NODES ARE TO BE DELETED?0
HOW MANY NODES ARE THERE WITH ALL THE LINES DELETED?0


=================== CABLEDATA ASSOCIATES ========================

                ARPANET COST ANALYSIS MODEL

                   OCTOBER  11  ,  1973
              DATA BASE ACCURATE AS OF 6-73

                    SUMMARY OF INPUTS

MONTH OF EVALUATION (M) ----  19   OR  6   - 1971
COSTING BASIS --------------  F -- FULLY ALLOCATED
DEPRECIATION RATE ----------  5    YEAR, STRAIGHT LINE
INVESTMENT SCRAP VALUE -----  .1

========================== OUTPUTS ======================
$ PER MONTH PER SITE ---------------------- $    30,982
$ PER MONTH TOTAL ------------------------- $   340,798
TOTAL INVESTMENT TO DATE ------------------ $   943,000
TOTAL DEPRECIATION TO DATE ---------------- $    47,640
BOOK VALUE OF THE NETWORK ----------------- $   895,360
TOTAL INVESTMENT IN MONTH M --------------- $   199,000
AVERAGE INVESTMENT PER SITE IN MONTH M ---- $    18,091
NEW RENT ADDED IN MONTH M ----------------- $     3,922


      ****** SITE STATUS IN CALCULATIONS ******

          SITE NAME      NO. USED  DELETIONS
         UCLA            1    *
         SRI             2    *
         UCSB            3    *
         UTAH            4    *
         BBN             5    *
         MIT             6    *
         RAND            7    *
         SDC             8    *
         HARV            9    *
         LL             10    *
         MITR           17    *
```

ARPANET COST ANALYSIS MODEL

Example 4

OCTOBER 11 , 1973

DATA BASE ACCURATE AS OF 6-73

SUMMARY OF INPUTS

MONTH OF EVALUATION (M) ----	46	OR 10 - 1973
COSTING BASIS --------------	F --	FULLY ALLOCATED
DEPRECIATION RATE -----------	5	YEAR, STRAIGHT LINE
INVESTMENT SCRAP VALUE -----	.1	

========================= OUTPUTS =====================

$ PER MONTH PER SITE ------------------------	$	13,575
$ PER MONTH TOTAL ----------------------------	$	502,257
TOTAL INVESTMENT TO DATE -------------------	$	3,453,000
TOTAL DEPRECIATION TO DATE ----------------	$	1,033,470
BOOK VALUE OF THE NETWORK -----------------	$	2,419,530
TOTAL INVESTMENT IN MONTH M ---------------	$	0
AVERAGE INVESTMENT PER SITE IN MONTH M ----	$	0
NEW RENT ADDED IN MONTH M -----------------	$	0

****** SITE STATUS IN CALCULATIONS ******

SITE NAME	NO.	USED	DELETIONS
UCLA	1	*	
SRI	2	*	
UCSB	3	*	
UTAH	4	*	
BBN	5	*	
MIT	6	*	
RAND	7	*	
SDC	8	*	
HARV	9	*	
LL	10	*	
STAN	11	*	
ILL	12	*	
CASE	13	*	
CMU	14	*	
AMES	15	*	
AMES	16	*	
MITR	17	*	
RADC	18	*	
NBS	19	*	
ETAT	20	*	
TINK	21	*	
McCL	22	*	
USC	23	*	
GWC	24	*	
NOAT	25	*	
SDAT	26	*	
BELV	27	*	
ARPA	28	*	
ARPD	29	*	
BBN	30	*	
CCAT	31	*	
XRDX	32	*	
FNWC	33	*	
LBL	34	*	
UCSD	35	*	
HAWI	36	*	
RMLT	37	*	

ARPANET COST ANALYSIS MODEL

OCTOBER 11 , 1973

Example 5

DATA BASE ACCURATE AS OF 6-73

SUMMARY OF INPUTS

```
MONTH OF EVALUATION (M) ----  45     OR  10   - 1973
COSTING BASIS ---------------  L -- LONG TERM MARGINAL
DEPRECIATION RATE -----------  4     YEARS STRAIGHT LINE
INVESTMENT SCRAP VALUE -----  .1

======================== OUTPUTS ========================
$ PER MONTH PER SITE ---------------------- $      5,179
$ PER MONTH TOTAL ------------------------- $    130,249
TOTAL INVESTMENT TO DATE ------------------ $  3,453,000
TOTAL DEPRECIATION TO DATE ---------------- $  1,291,8[illegible]
BOOK VALUE OF THE NETWORK ----------------- $  2,161,162
TOTAL INVESTMENT IN MONTH M --------------- $          0
AVERAGE INVESTMENT PER SITE IN MONTH M ---- $          0
NEW RENT ADDED IN MONTH M ----------------- $          0
```

****** SITE STATUS IN CALCULATIONS ******

SITE NAME	NO.	USED	DELETIONS
UCLA	1	◆	
SRI	2	◆	
UCSB	3	◆	
UTAH	4	◆	
BBN	5	◆	
MIT	6	◆	
RAND	7	◆	
SDC	8	◆	
HARV	9	◆	
LL	10	◆	
STAN	11	◆	
ILL	12	◆	
CASE	13	◆	
CMU	14	◆	
AMES	15	◆	
AMES	16	◆	
MITR	17	◆	
RADC	18	◆	
NBS	19	◆	
ETAT	20	◆	
TINK	21	◆	
McCL	22	◆	
USC	23	◆	
GWC	24	◆	
NOAT	25	◆	
SDAT	26	◆	
BELV	27	◆	
ARPA	28	◆	
ABRD	29	◆	
BBN	30	◆	
CCAT	31	◆	
XROX	32	◆	
FNWC	33	◆	
LBL	34	◆	
UCSD	35	◆	
HAWI	36	◆	
RMLT	37	◆	

Example 6

```
RUN
RCM1

 DO YOU WANT INSTRUCTIONS ( Y / N ) ?N
        DEPRECIATION RATE ( S OR D ) ?D
       DEPRECIATION PERIOD ( YEARS ) ?5
     SCRAP VALUE  (DECIMAL FRACTION) ?0
     COSTING BASIS  ( S , L , OR F ) ?F
                       MONTH NUMBER = ?46
HOW MANY NODES ARE TO BE DELETED?0
HOW MANY NODES ARE THERE WITH ALL THE LINES DELETED?0
```

```
=================== CABLEDATA ASSOCIATES =========================

                 ARPANET COST ANALYSIS MODEL

                      OCTOBER  12  ,  1977
                DATA BASE ACCURATE AS OF 6-73

                      SUMMARY OF INPUTS

MONTH OF EVALUATION (M) ----  46    OR  10   - 1977
COSTING BASIS ---------------  F -- FULLY ALLOCATED
DEPRECIATION RATE -----------  5    YEAR, SUM OF THE DIGITS
INVESTMENT SCRAP VALUE ------  0

========================== OUTPUTS ======================
$ PER MONTH PER SITE ------------------------ $     11,247
$ PER MONTH TOTAL --------------------------- $    442,043
TOTAL INVESTMENT TO DATE -------------------- $  3,453,000
TOTAL DEPRECIATION TO DATE ------------------ $  1,834,554
BOOK VALUE OF THE NETWORK ------------------- $  1,618,446
TOTAL INVESTMENT IN MONTH M ----------------- $          0
AVERAGE INVESTMENT PER SITE IN MONTH M ---- $          0
NEW PLANT ADDED IN MONTH M ------------------ $          0
```

◆◆◆◆◆◆ SITE STATUS IN CALCULATIONS ◆◆◆◆◆◆

SITE NAME	NO.	USED	DELETIONS
UCLA	1	◆	
SRI	2	◆	
UCSB	3	◆	
UTAH	4	◆	
BBN	5	◆	
MIT	6	◆	
RAND	7	◆	
SDC	8	◆	
HARV	9	◆	
LL	10	◆	
STAN	11	◆	
ILL	12	◆	
CASE	13	◆	
CMU	14	◆	
AMES	15	◆	
AMES	16	◆	
MITR	17	◆	
RADC	18	◆	
NBS	19	◆	
ETAT	20	◆	
TINK	21	◆	
McCL	22	◆	
USC	23	◆	
GWC	24	◆	
NOAT	25	◆	
SDAT	26	◆	
BELV	27	◆	
ARPA	28	◆	
ABRD	29	◆	
BBN	30	◆	
CCAT	31	◆	
XROX	32	◆	
FNWC	33	◆	
LBL	34	◆	
UCSD	35	◆	
HAWI	36	◆	
RMLT	37	◆	